



# Environmental Conditions Update

OCTOBER 2000

## Environmental Monitoring and Assessment Division South Florida Water Management District



*The Water Quality Conditions Quarterly Report has been renamed to Environmental Conditions Update. The name change was made to more accurately reflect the broader coverage of environmental information being reported. This issue analyzes environmental data collected from April 1 through June 30, 2000. The major hydrologic event of the quarter was the lowering of Lake Okeechobee to promote the re-establishment of native submerged vegetation in the lake's littoral zone to benefit the ecosystem. The majority of the water from Lake Okeechobee was released to the St. Lucie and Caloosahatchee Estuaries. Since these estuaries are not covered in this update please refer to [Outflow and Estuaries Page](#) on the District's Web site. Information on water released southward from the lake to the Everglades Agricultural Area and the Water Conservation Areas is included in this quarterly update.*

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# RAINFALL

## SUMMARY

Monthly rainfall totals, for April, May and June 2000 in various rainfall basins and stormwater treatment areas, are presented in **Table 1**. The totals are weighted averages of data from rainfall gages and are reported in the South Florida Water Management District daily rainfall report. The report is compiled by Water Resources Operations and also includes data from other agencies collecting rainfall data in South Florida.

Historically, rainfall in South Florida during the dry months (November through April) has been generally associated with occasional disturbances such as cold fronts. During the wet months (June through September) rainfall is attributed to frequent thunderstorms. May and October have been considered transitional months and can be either wet or dry.

A five-month period of below average rainfall ended in April 2000. Ninety-five percent of the month's rain fell from April 12 through 16. Overall, District-wide rain events averaged 3.09 inches, or 134 percent of the monthly historical average. Drier-than-normal conditions returned in May with District-wide rainfall averaging only 1.26 inches, or 26 percent of the monthly historical average. The 1999-2000 dry season was the driest since 1966-67. Rainfall totaled 10.76 inches during this season, 56 percent of the historic average. Although rainfall increased in June to a District-wide average of 6.07 inches, it was only 73 percent of the monthly historical average. The effects of the below-average rainfall can be observed in low inflows and total phosphorus loads entering Lake Okeechobee (**Figure 2**) and low phosphorus loads calculated for the Everglades Agricultural Area (EAA) (**Figure 8**).

**Table 1.** Monthly weighted rainfall averages (inches).

Rainfall Basin	Jul-99	Aug-99	Sep-99	Oct-99	Nov-99	Dec-99	Jan-00	Feb-00	Mar-00	Apr-00	May-00	Jun-00	12-Month Moving Total
Upper Kissimmee	2.5	4.3	10.0	2.5	7.7	6.4	1.2	0.2	0.8	1.5	1.2	6.7	44.9
Lower Kissimmee	2.4	3.6	11.6	3.9	8.4	7.0	1.2	0.2	1.5	1.7	0.5	4.4	46.4
Lake Okeechobee	2.4	3.7	12.5	5.1	7.4	7.4	1.1	0.6	1.8	3.3	0.9	4.5	50.7
East EAA	1.1	4.4	11.9	5.5	5.1	9.2	1.0	0.8	2.3	4.8	1.6	4.8	52.5
West EAA	1.0	5.8	15.0	6.9	8.9	13.1	0.9	0.9	1.6	5.1	1.6	6.1	67.0
WCAs 1&2	1.3	2.9	17.1	3.2	7.5	8.6	1.2	0.4	5.7	3.8	1.0	4.1	56.7
WCA 3	1.6	3.7	13.3	4.5	8.1	9.5	0.7	1.1	2.4	5.4	0.9	7.3	58.4
ENP	1.2	4.8	12.3	12.8	<b>12.1</b>	<b>8.4</b>	0.4	0.5	1.0	3.6	2.0	6.9	66.0
C111 Basin	1.10	5.9	10.1	0.0	3.9	2.4	0.6	0.9	1.6	3.6	1.9	6.6	38.6
STA-1W	1.2	2.7	12.1	2.5	5.7	6.1	0.7	0.8	3.7	4.4	0.9	1.4	42.2
STA6	0.8	11.0	14.9	4.8	9.5	3.4	0.3	1.0	2.3	3.6	0.4	4.7	56.7

*Italized and bolded values are based on estimate average of rainfall at stations CHEKKA, EVER and S332R*

# LAKE OKEECHOBEE DRAINAGE BASIN

## SUMMARY

## MAP

### Phosphorus Loading and Rainfall Trends

Historic and monthly data for rainfall, flows and phosphorus loads to Lake Okeechobee are presented for 1999 (**Figure 1**) and the first half of 2000 (**Figure 2**). In both figures, monthly values for each of these parameters are depicted as bars. Solid lines represent monthly means based on the previous 20-years of data. A 20-year period was chosen because it provided a quality assured data set for water quality and covered both drought and wet conditions. The dashed and dotted lines in each figure depict the 95 percent confidence interval about this 20-year mean. In other words, a 95% chance exists that a value will fall within that confidence level. **Figures 1** and **2** display the expected range of data for the 20-year period.

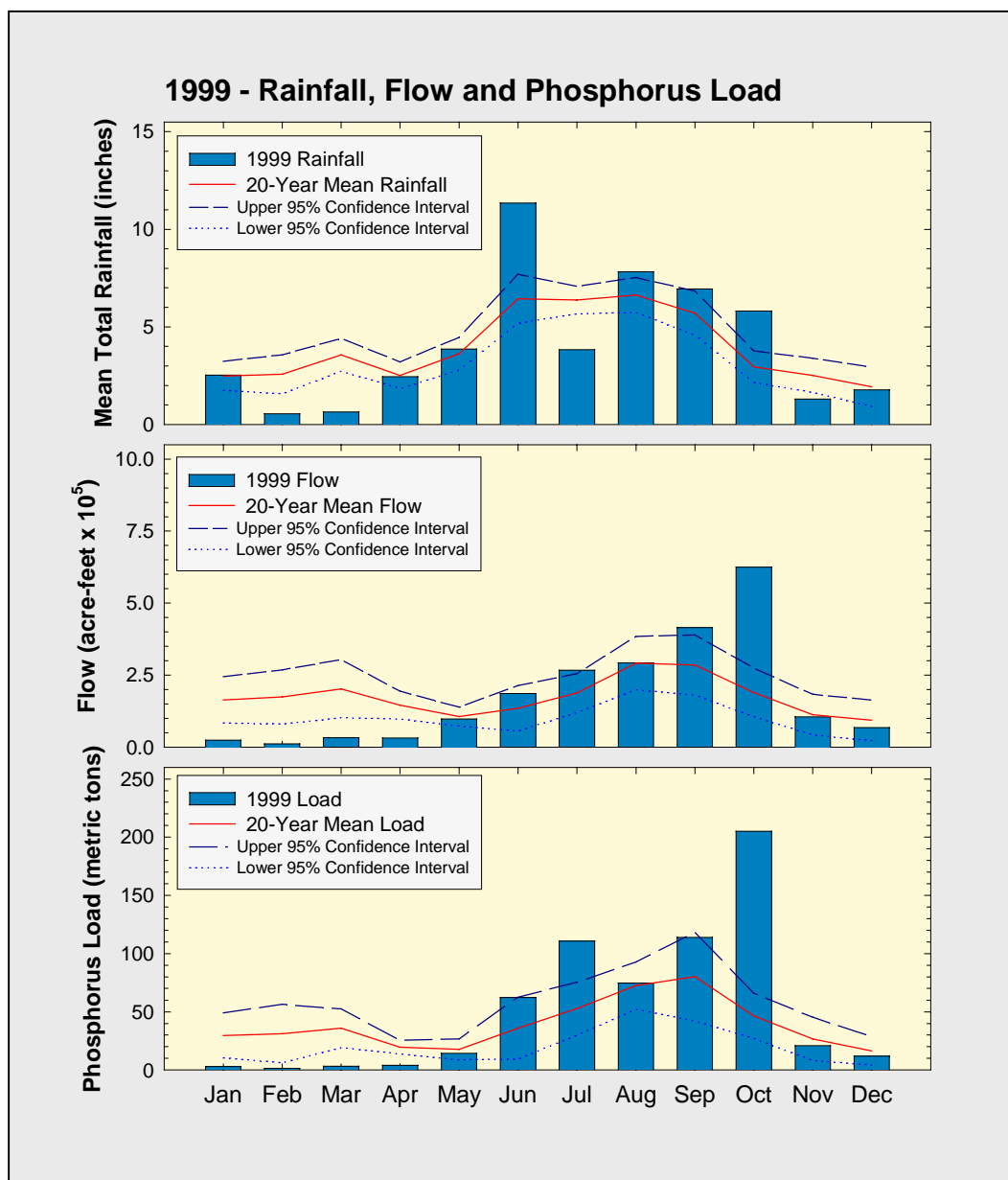
Monthly rainfall shown in each of the figures is presented as area-weighted averages from a network of meteorological stations in the Upper Kissimmee, Lower Kissimmee and Lake Okeechobee basins. Flows are compiled from directly measured data at 26 monitoring stations that discharge into the lake. Phosphorus loads to the lake were calculated by multiplying concentration data from those 26 monitoring stations and their respective flow data.

Higher phosphorus loads have typically occurred during wetter months (June through October), while lower loads occur during drier months of the year (**Figures 1** and **2**). In 1999, the period from June through October, excluding July, exhibited higher rainfall than the 20-year average for these months. As a result, both flows and phosphorus loads for these five months were greater than their 20-year means (**Figure 1**).

Major climatic disturbances (such as El Niño, tropical storms and hurricanes) can alter the seasonal distribution of phosphorus to Lake Okeechobee. During October 1999, scheduled releases of water from Lake Kissimee combined with Hurricane Irene contributed to the 205 metric tons of phosphorus released to Lake Okeechobee (**Figure 1**).

During the second quarter 2000, monthly rainfall amounts for April, May and June 2000 were 2.2, 0.8 and 5.2 inches, respectively, across the Lake Okeechobee Basin (**Figures 1** and

2). In 1999, the rainfall amounts were 2.5, 3.9, and 11.41 inches respectively, approximately two times more than the totals in 2000. The amount of rainfall recorded for April 2000 was within the expected range for that month, based on the previous 20 years of data (**Figure 2**). However, May and June had rainfall amounts below their expected range (**Figure 2**). The lowest monthly rainfall recorded during the present reporting period was in May. This amount was approximately four times lower than the 20-year average for May. Although 5.2 inches of rainfall were recorded in June, this amount was less than the expected range for that



**Figure 1.** Monthly rainfall, flow and total phosphorus load for Lake Okeechobee.

month. Additionally, rainfall for June 2000 was approximately 1.5 inches lower than the 20-year average (**Figure 2**).

Lower rainfall during the second quarter of 2000 also resulted in low flows and phosphorus loads to the lake (**Figure 2**). Phosphorus loads to Lake Okeechobee in April, May and June 2000 were 16.7, 2.2 and 4.8 metric tons, respectively, compared to 3.9, 14.5 and 60.4 metric tons during the same months in 1999.

Approximately 53 percent of the phosphorus load in April 2000 entered the lake through the S65E structure. The structure also accounted for approximately 70 percent of the inflow volume. During May and June 2000, the majority of the phosphorus load to the lake resulted from backflow of C-44 canal water. As the discharges at structure S80 decreased, water levels in the canal were higher than in Lake Okeechobee resulting in water moving back to the lake from the canal. The phosphorus load during the second quarter of 2000 was approximately three times lower than the 20-year average for the same period (**Figures 1 and 2**).

On April 25, 2000, the Governing Board at the South Florida Water Management District passed the Shared Adversity Plan (Resolution No. 00-31). Under this plan, the water level in Lake Okeechobee would be lowered to 13.0 feet NGVD and held at this level or lower for at least eight weeks. The primary objectives for lowering the lake's water level were to re-establish submerged plant beds along the south and west lakeshore and improve water quality. The lake's elevation was 14.89 feet NGVD at the beginning implementation of the plan on April 25. By June 30, the water level in Lake Okeechobee was 11.9 feet NGVD (**Figure 3a**). Thirty four percent of the change in the lake stage was due to lake lowering operations, thirty eight percent was due to evapotranspiration and twenty eight percent was delivered to water supply users.

**Figures 3b and 3c** summarize flows and phosphorus loads entering into and being released from Lake Okeechobee during the second quarter of 2000, which includes the lowering of the lake. Under the Shared Adversity Plan, water was released from Lake Okeechobee primarily through these seven structures: C10A, S352, S351, S354, INDUSCAN, S308 and S77. Approximately 175 metric tons of phosphorus were released from Lake Okeechobee through these structures, while 24 metric tons entered the lake during the second quarter of 2000. Half of the phosphorus load released from the lake went through S77 and into the Caloosahatchee River Estuary (**Figure 3c**). The remaining 50 percent of the phosphorus load was released through the other six structures.

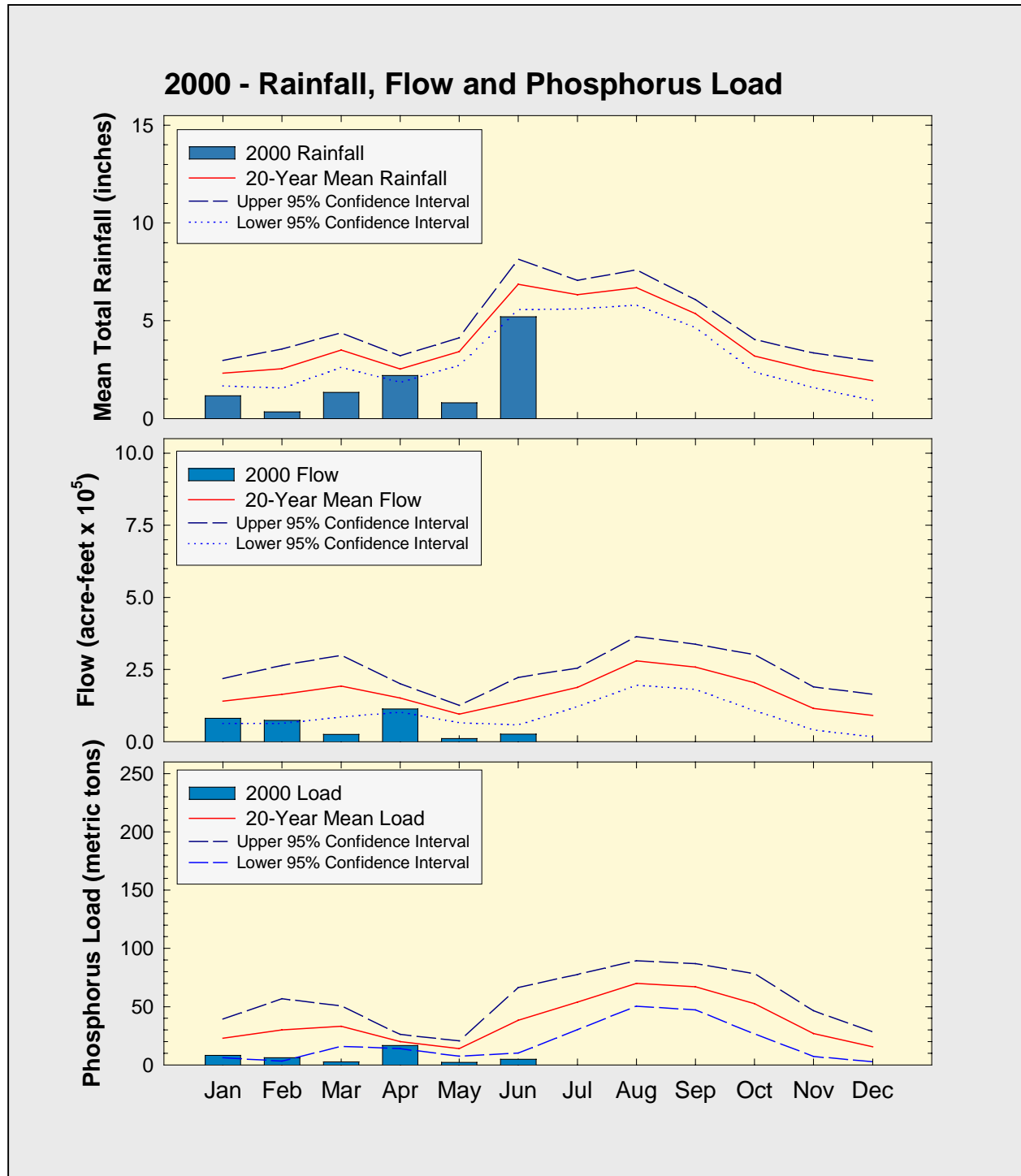
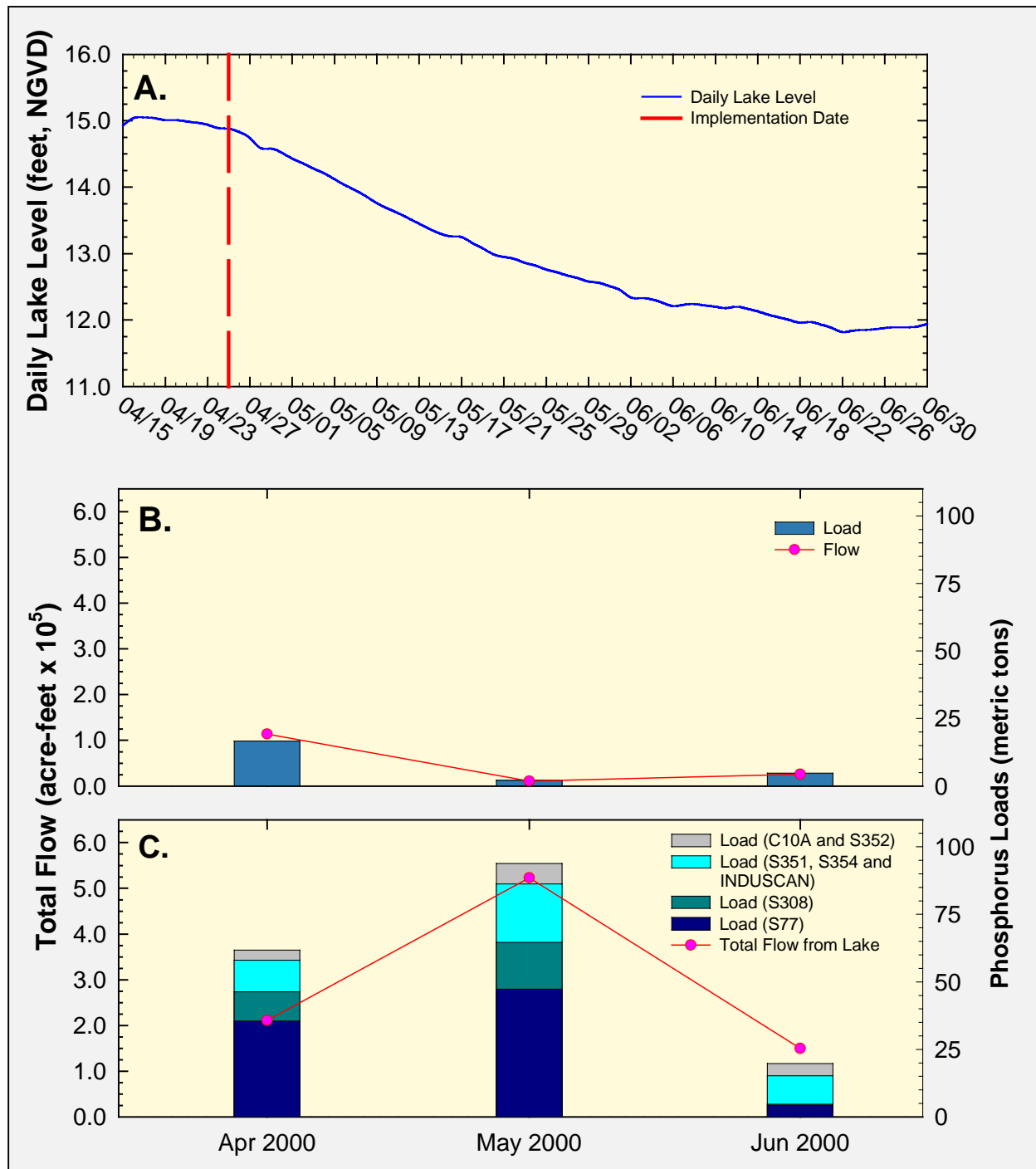


Figure 2. Monthly rainfall, flow and total phosphorus load for Lake Okeechobee.



**Figure 3.** (a) Water elevations in Lake Okeechobee from April 15 to June 30, 2000. The sum of monthly phosphorus loads and flows for the second quarter of 2000 at (b) inflow structures and (c) outflow structures.

## Phosphorus Concentrations for Tributaries and Basins

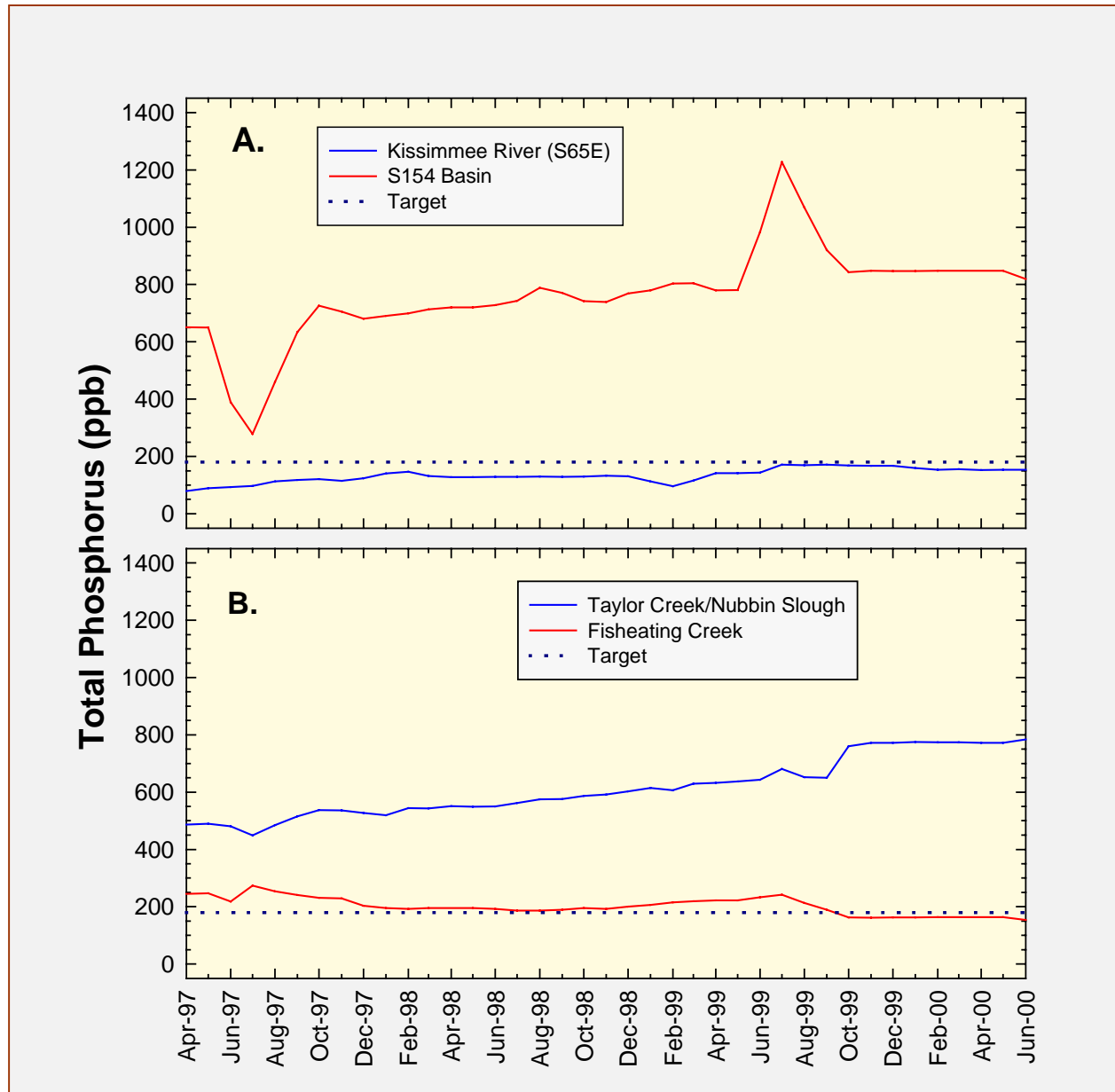
A phosphorus concentration target for each basin in the Lake Okeechobee Watershed was established under the 1989 Interim Surface Water Improvement and Management (SWIM) Plan. This target was incorporated to ensure a reduction in phosphorus loads to Lake Okeechobee. Under this SWIM Plan, the phosphorus concentration from each basin must either be below 180 parts-per-billion (ppb) or at the 1989-discharge concentration, whichever is less.

The Lower Kissimmee River, S65E, S154, Fisheating Creek and Taylor Creek/Nubbin Slough Basins are major contributors of phosphorus load into the lake. Flow-weighted mean concentrations of total phosphorus from these four basins were used to calculate the 12-month moving average concentrations shown in **Figure 4**. These concentrations are compared to the 180-ppb respective target (**Figure 4**).

Since May 1991, the phosphorus concentrations for the Kissimmee River Basin have consistently been at or below the target concentration of 180-ppb (**Figure 4a**). During the first half of 2000, the phosphorus concentrations from the S-154 Basin were about 850 ppb, except for a slight decrease in June (**Figure 4a**).

The moving average phosphorus concentrations in Fisheating Creek have varied above and below the 180-ppb target level. From October 1996 through September 1999, the phosphorus concentrations in the creek were consistently above the target (**Figure 4b**). Since October 1999, the phosphorus concentrations have remained below the target limit.

A sharp increase in phosphorus concentrations from about 650-ppb to over 750-ppb was observed for the Taylor Creek/ Nubbin Slough Basin beginning in September 1999 (**Figure 4b**). A slight increase in phosphorous concentrations occurred during the second quarter of 2000.



**Figure 4.** Twelve-month moving flow-weighted mean total phosphorus concentrations for: a. Kissimmee River and S154 Basins and b. Taylor Creek/ Nubbin Slough and Fisheating Creek. The four basins/tributaries drain into Lake Okeechobee.

## In-Lake Total Phosphorus Concentrations

Lake Okeechobee has a long history of excessive phosphorus loading, which has resulted in major changes in the ecosystem, including an increased frequency of algal blooms, predominantly blue-green algae, and the accumulation of over 30,000 metric tons of phosphorus in the lake sediments. From the early 1970s to the 1990s, total phosphorus concentrations in the lake's water column increased from below 50 ppb to over 100 ppb. Present high total phosphorous concentrations are a function of high external loads and frequent resuspension of phosphorous-rich mud bottom sediments caused by wind. The South Florida Water Management District and other agencies have initiated an aggressive program to reduce external phosphorus loads to the lake and are conducting a feasibility study to determine the ecological, engineering and economic implications of reducing the internal phosphorous load from the lake's sediments.

In order to assess the seasonal and spatial variations in phosphorus concentrations in the lake resulting from inputs as well as internal cycling, distribution plots of open-water total phosphorus concentrations are presented in **Figures 5a** through **5c**.

The arithmetic mean concentration of total phosphorus in Lake Okeechobee was 191, 77 and 91 ppb for April, May and June, respectively. By comparison, total phosphorous concentrations in 1999 for the same months were 78, 71 and 72 ppb, respectively. The higher concentrations for the Spring season of 2000 are believed to represent the lingering effects of Hurricane Irene ([SFWMD, 2000b](#)).

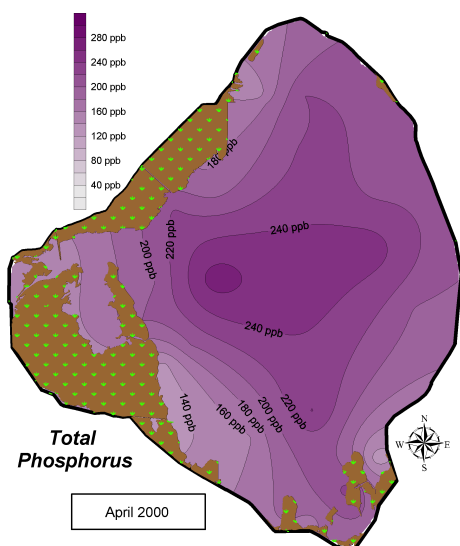
The contour plot shown in **Figure 5a** depicts total phosphorus concentrations in Lake Okeechobee for April 2000 prior to its lowering. All total phosphorus concentrations measured for this month, prior to the regulated release, were greater than 100 ppb with the highest concentrations occurring in the central portion of the lake (**Figure 5a**). Approximately 82 percent of these phosphorus measurements had concentrations greater than 160 ppb.

Total phosphorus concentrations throughout the lake decreased dramatically in May, which was the time when the most water was discharged to lower the lake (**Figure 3**). Approximately 55 percent of phosphorus concentrations measured for May were below 100 ppb, and 99 percent of the lake's surface exhibited concentrations less than 160 ppb (**Figure 5b**). Also, shallower near shore areas exhibited phosphorous concentrations below 40 ppb.

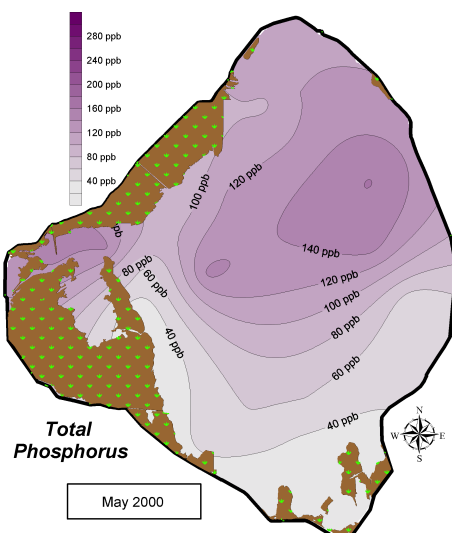
In June, total phosphorus concentrations in the lake slightly increased. The increase coincides with lower discharges from the lake. Approximately 94 percent of the lake had total phosphorus

concentrations less than 160 ppb with higher total phosphorus concentrations occurring in the northeastern section of the lake (**Figure 5c**).

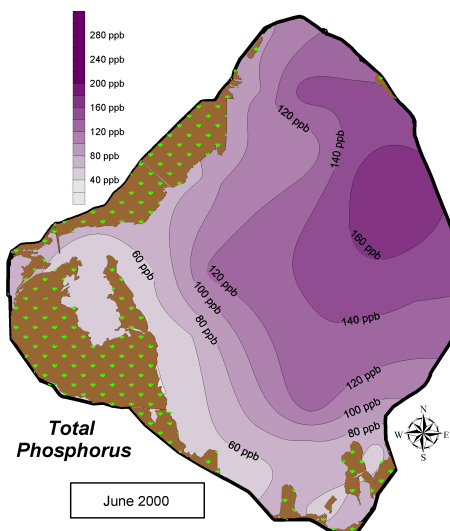
The higher phosphorus concentrations specifically observed during April also reflect the lingering effects of Hurricane Irene. The strong winds generated from this storm resuspended a large mass of the sediment mud layer into the water column. The thickness of this mud layer ranges from 10 to 80 centimeters (cm). The upper 10 to 15 cm of the sediments can be resuspended easily. Because the sediments in the lake are fine-grained and phosphorus-rich, any resuspension will result in elevated phosphorus levels. The central portion of Lake Okeechobee is the most susceptible to this phenomenon.



**Figure 5a.**  
Total phosphorus  
concentrations for  
open water  
monitoring sites  
in Lake  
Okeechobee,  
April 2000.



**Figure 5b.**  
Total phosphorus  
concentrations  
for open water  
monitoring sites  
in Lake  
Okeechobee,  
May 2000.



**Figure 5c.**  
Total  
phosphorus  
concentrations  
for open water  
monitoring  
sites in Lake  
Okeechobee,  
June 2000.

## Light Penetration

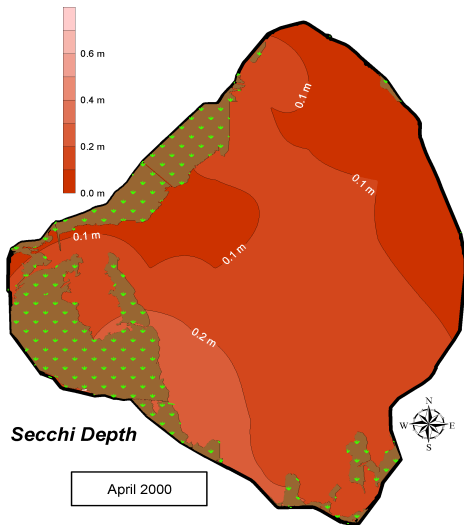
Secchi depth is a measure of how deep light penetrates the water column. The Secchi depth is measured by lowering a 30-cm diameter white disk through the water column until it is just visible. At the Secchi depth, solar light penetrating the water is reflected off the surface of the disk in a quantity sufficient to come back through the water and reach the observer's eye. The amount and composition of suspended material along with the presence of dissolved colored substances in the water column affect Secchi depth. When either of these two variables is high, light will not penetrate deeply into the water column (i.e., Secchi depth decreases).

The transmission of light in lakes and other bodies of water is extremely important because solar radiation is the primary source of energy for photosynthetic organisms such as algae and aquatic plants. An increase in light penetration can cause increased photosynthetic activity, resulting in higher primary productivity if nutrients are not limiting.

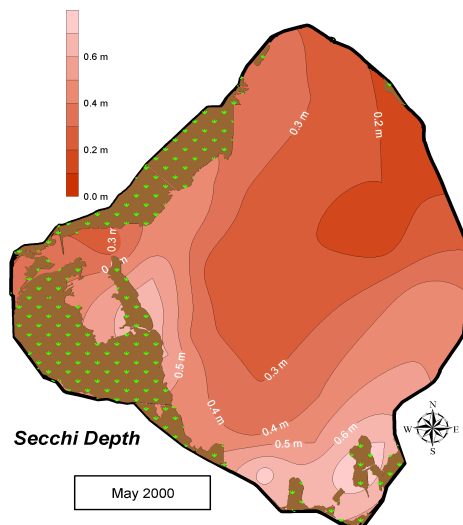
During the second quarter of 2000, Secchi depths in the lake increased. The average Secchi depths measured for this quarter were 0.15 meters in April and 0.44 meters in both May and June (**Figures 6a** through **6c**).

Light penetration in Lake Okeechobee extended down to a maximum depth of 0.2 meters during the April 2000 monitoring event (**Figure 6a**). Light penetrated to less than 0.1 meters in depth over approximately 88 percent of the lake.

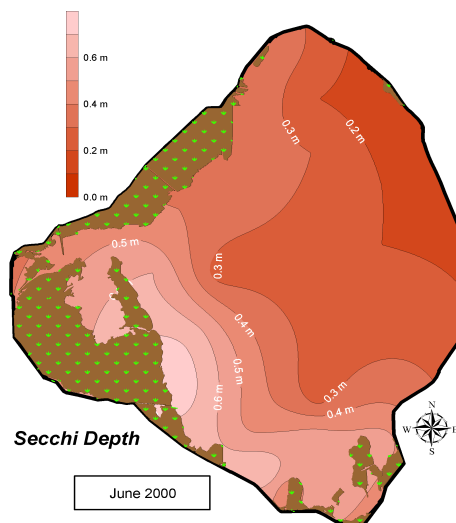
Secchi depths of 0.4 to 0.6 meters occurred in over 40 percent of the lake for the month May and June monitoring events (**Figures 6b** and **6c**). An inverse relationship appears to exist between Secchi depth and total phosphorous at mid-lake. In other words, as Secchi depths increase in this portion of the lake, total phosphorous concentrations decrease. Biological uptake of phosphorous in the shallower near-shore areas may play a more important role in controlling phosphorous concentrations. Also, phytoplankton may play a greater role in light penetration for the lake.



**Figure 6a.**  
Depth of light  
penetration (Secchi  
depth) measured in  
meters for Lake  
Okeechobee,  
April 2000.



**Figure 6b.**  
Depth of light  
penetration (Secchi  
depth) measured in  
meters for Lake  
Okeechobee,  
May 2000.



**Figure 6c.**  
Depth of light  
penetration (Secchi  
depth) measured in  
meters for Lake  
Okeechobee,  
June 2000.

## Chlorophyll *a* Concentrations

Chlorophyll *a* is a green pigment present in terrestrial and aquatic plants, including algae. This pigment functions to absorb visible light. The energy associated with the absorbed light is used to drive photosynthesis. Chlorophyll *a* concentrations are an indicator of the amount of living plant (or algal) material in a water body.

Naturally occurring algal populations present in Lake Okeechobee will form blooms under certain weather and water quality conditions.

Algal blooms are dense concentrations of algae over large areas of a water body. Blooms might be composed of undesirable species that are harmful to other aquatic life, possibly form nuisance scums on the water surface and create taste and odor in the drinking water supply. If algal populations are large enough, they can also reduce oxygen levels in the water column during algal die-off resulting in invertebrate and fish kills.

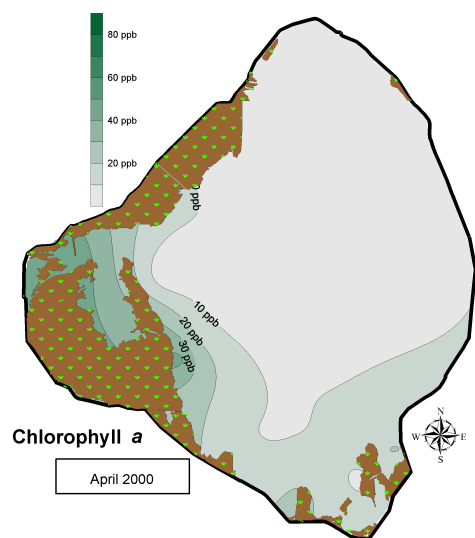
Severe bloom conditions generally occur when chlorophyll *a* concentrations exceed 60 ppb. Concentrations between 40 and 60 ppb are indicative of moderate bloom conditions. The occurrence and effects of these bloom conditions on the lake depend on a variety of factors. Persistence of bloom conditions over large areas may indicate increased nutrient concentrations.

Lake-wide chlorophyll *a* distributions at 15 open water and 15 littoral water quality monitoring stations for April through June 2000 are presented in **Figures 7a** through **7c**. During these three months, mean chlorophyll *a* levels in Lake Okeechobee were 12.8 ppb in April, 24.3 ppb in May and 30.4 ppb in June. These levels are higher than those reported during the same period in 1999.

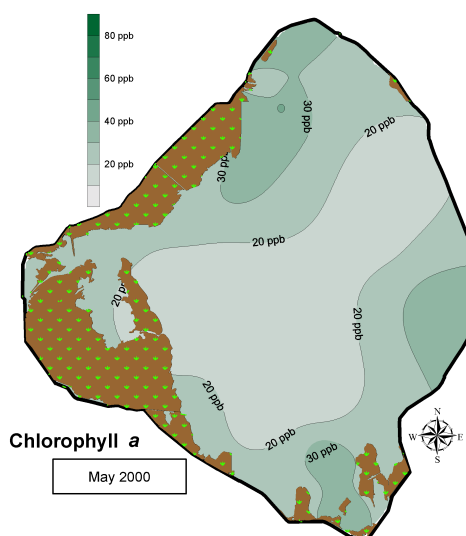
A moderate bloom condition was observed within Fisheating Bay (located in the southwestern portion of the lake) during April 2000 (**Figure 7a**). This bloom covered approximately 7 percent of the lake's surface water. More than 80 percent of the lake during April had chlorophyll *a* concentrations below 20 ppb.

Although only 3 percent of the lake exhibited a moderate bloom condition in May, approximately 63 percent of the surface water had chlorophyll *a* levels between 20 and 40 ppb (**Figures 7b**). The observed increase in chlorophyll levels during this month may be associated with the release of water from the lake. As the water was released from the lake, suspended sediment levels decreased, resulting in a concomitant increase in light penetration. By June, moderate and severe bloom conditions existed in the lake. The western and southern portion of the lake exhibited these bloom conditions (**Figure 7c**). Approximately 23 percent of the lake surface water exhibited chlorophyll *a* levels greater than 40 ppb.

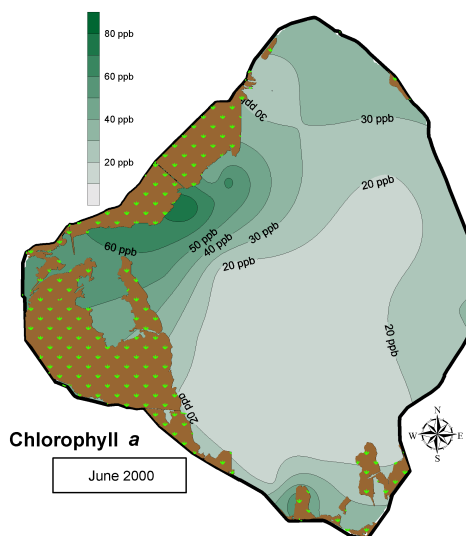
The growth of algal material during the second quarter of 2000 was probably limited by the amount of light that could penetrate the water column. Because of sediment resuspension, light penetration was reduced resulting in lower photosynthetic activity in the water column. Low chlorophyll *a* concentrations in the lake coincide with areas having high phosphorus concentrations and low Secchi depths. As the Secchi depths increased due to lower suspended solids, chlorophyll *a* levels increased.



**Figure 7a.**  
Chlorophyll *a* levels at  
open water monitoring  
sites in Lake  
Okeechobee,  
April 2000.



**Figure 7b.**  
Chlorophyll *a* levels  
at open water  
monitoring sites in  
Lake Okeechobee,  
May 2000.



**Figure 7c.**  
Chlorophyll *a* levels  
at open water  
monitoring sites in  
Lake Okeechobee,  
June 2000.

# EVERGLADES AGRICULTURAL AREA

## SUMMARY

## MAP

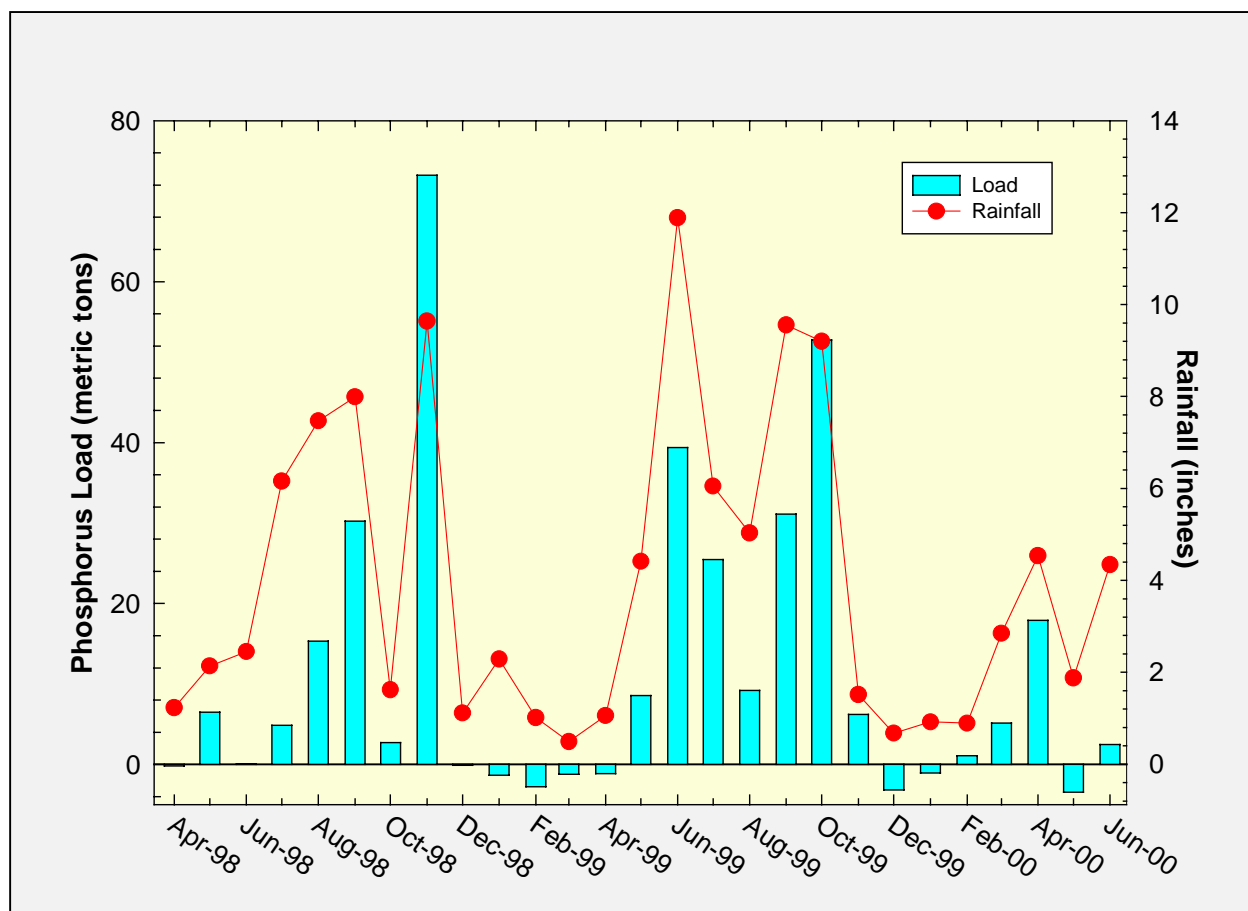
### Phosphorus Loading Trends

The Everglades Best Management Practices (BMP) Program (Rule 40-E, 63, Florida Administrative Code) for the Everglades Agricultural Area (EAA) requires that the EAA basin achieve a 25 percent reduction in total phosphorus (TP) load discharged to the Everglades. The reduction is determined by comparing phosphorus discharges at the end of each 12-month water year period (May 1 through April 30) with the pre-BMP base period of October 1, 1978, through September 30, 1988. The first full year of BMP implementation was water year 1996.

The second quarter of 2000 was relatively dry compared to previous years. April rainfall (4.5 inches) was higher than the historical average, while May was an extremely dry month (1.9 inches). Total rainfall for the quarter was only 10.8 inches.

The release of water from Lake Okeechobee as part of the Shared Adversity Plan during the second quarter of 2000, caused minor effects on the EAA Basin, with respect to water quality. Approximately 297,000 acre-feet of lake water were released through S351 and S354, combined, to the EAA canals. In comparison, 100,000 acre-feet of water were discharged from the EAA through S6, S7 and S8 to the Water Conservation Areas (WCA's). The total phosphorous load for April was the highest since October 1999 due to the rainfall previously described (**Figure 8**). The EAA received more total phosphorous in May than was discharged, creating what appears to be a load less than zero. The June load increased in response in increased rainfall.

Total phosphorus loads and flows measured at District pump stations S5A, S6, S7, S150, and S8 (see map), which convey a majority of the water from the EAA to the WCAs, are presented in **Figure 9**. The flow-weighted mean total phosphorus concentrations released from these stations into the WCA's are presented in **Figure 10**.



**Figure 8.** Monthly phosphorus loads calculated for the EAA Basin and monthly rainfall for the EAA

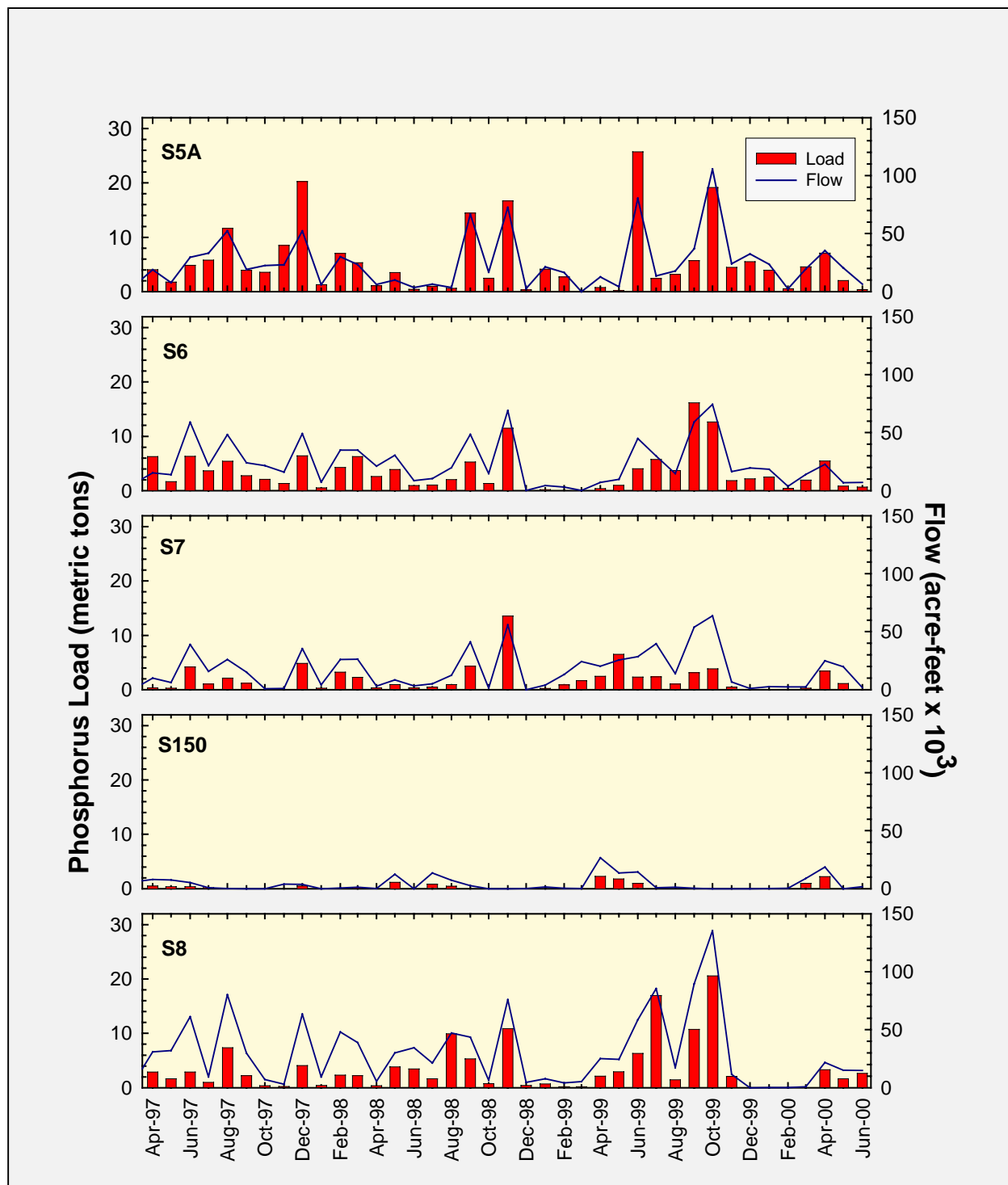
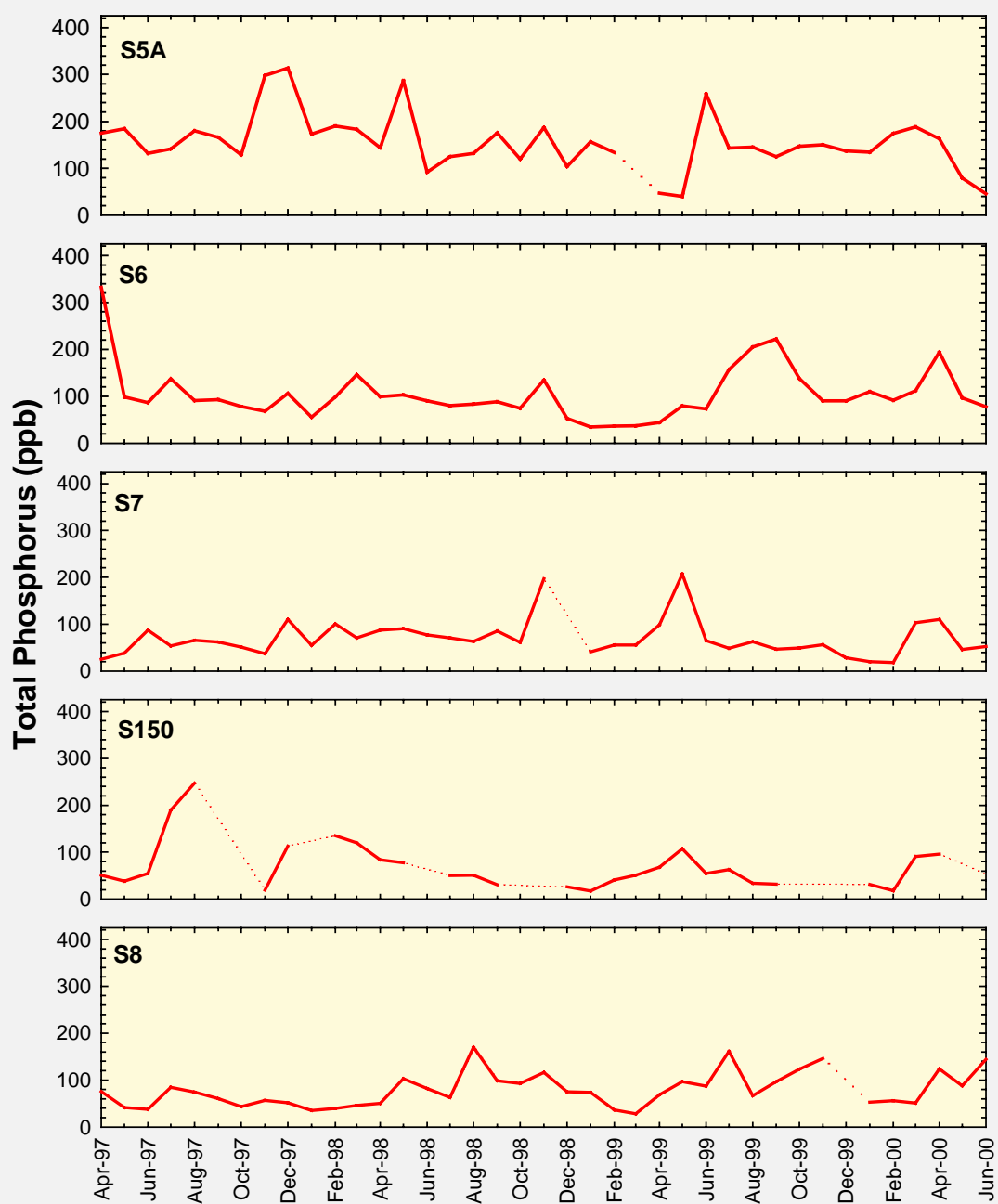


Figure 9. Monthly flows and calculated phosphorus loads at major EAA pump stations.



**Figure 10.** Monthly flow-weighted mean total phosphorus concentrations at major EAA pump stations (dashed lines indicate missing data).

A summary of monthly flows measured at each structure during the second quarter of 2000 is presented in **Table 2**. In addition, total phosphorus loads for each structure during the reporting period are summarized in **Table 3**. Flow-weighted mean total phosphorus concentrations determined at the four pump stations during the second quarter of 2000 are presented in **Table 4**.

**Table 2. EAA Pump Station  
Flows (k-acft)**

	Apr-00	May-00	Jun-00
<b>S5</b>	35.4	20.5	6.4
<b>S6</b>	22.7	6.9	7.0
<b>S7</b>	24.9	19.8	1.7
<b>S150</b>	18.7	0.0	1.7
<b>S8</b>	21.7	15.0	14.9
<b>Sum</b>	<b>123.4</b>	<b>62.2</b>	<b>31.7</b>

**Table 3. EAA Pump Station  
TP Loads (metric tons/month)**

	Apr-00	May-00	Jun-00
<b>S5</b>	7.1	2.0	0.4
<b>S6</b>	5.4	0.8	0.7
<b>S7</b>	3.4	1.1	0.1
<b>S150</b>	2.2	0.0	0.1
<b>S8</b>	3.3	1.6	2.6
<b>Sum</b>	<b>21.4</b>	<b>5.6</b>	<b>3.9</b>

**Table 4. EAA Pump Station Flow-  
weighted Mean TP  
Concentrations (ppb)**

	Apr-00	May-00	Jun-00
<b>S5</b>	163	79	46
<b>S6</b>	194	97	78
<b>S7</b>	110	46	52
<b>S150</b>	96	N/A	53
<b>S8</b>	124	88	144

# STORMWATER TREATMENT AREA 1 WEST

## SUMMARY

## MAP

### Cell 5

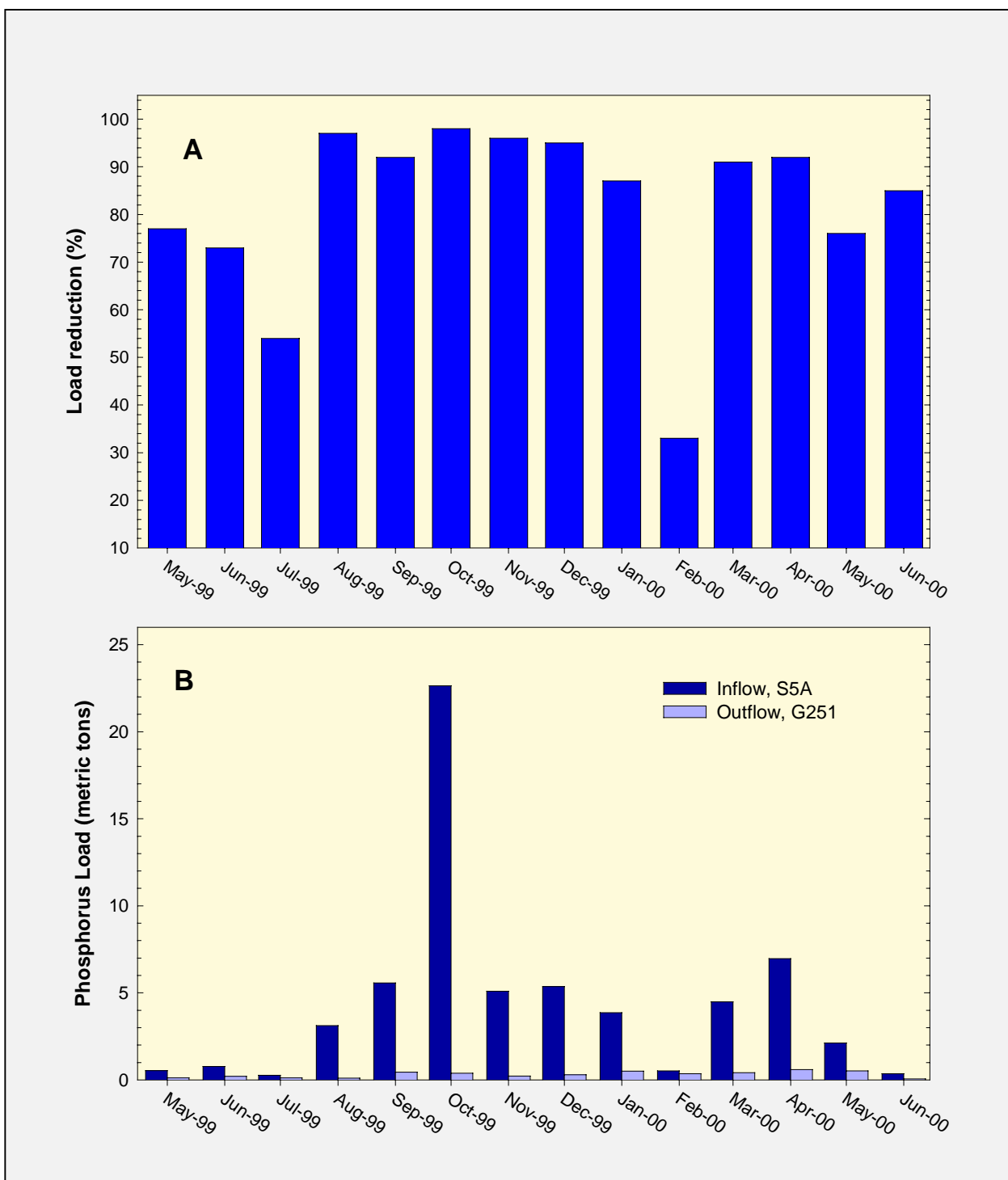
Stormwater Treatment Area 1 West (STA-1W) encompasses the four treatment cells of the Everglades Nutrient Removal Project (ENR) plus newly constructed treatment Cell 5 creating a total effective treatment area of 6,870 acres. The permit for the ENR expired at the end of April 1999. The STA-1W permit went into effect on May 11, 1999. Cell 5 passed the start-up phase of operation for both phosphorus and mercury during the week of January 17, 2000.

In accordance with construction plans, the inflows to STA-1W were diverted July 12, 1999, from pump station G250 to inflow structure G302, a component of the new Inflow and Distribution Works for STAs-1W and 1E. As a result of the diversion, pump station S5A became the inflow monitoring station for STA-1W. The outflow site (G251) from the ENR remains operational within STA-1W. The new STA-1W outflow (G310) has not yet begun routine discharges.

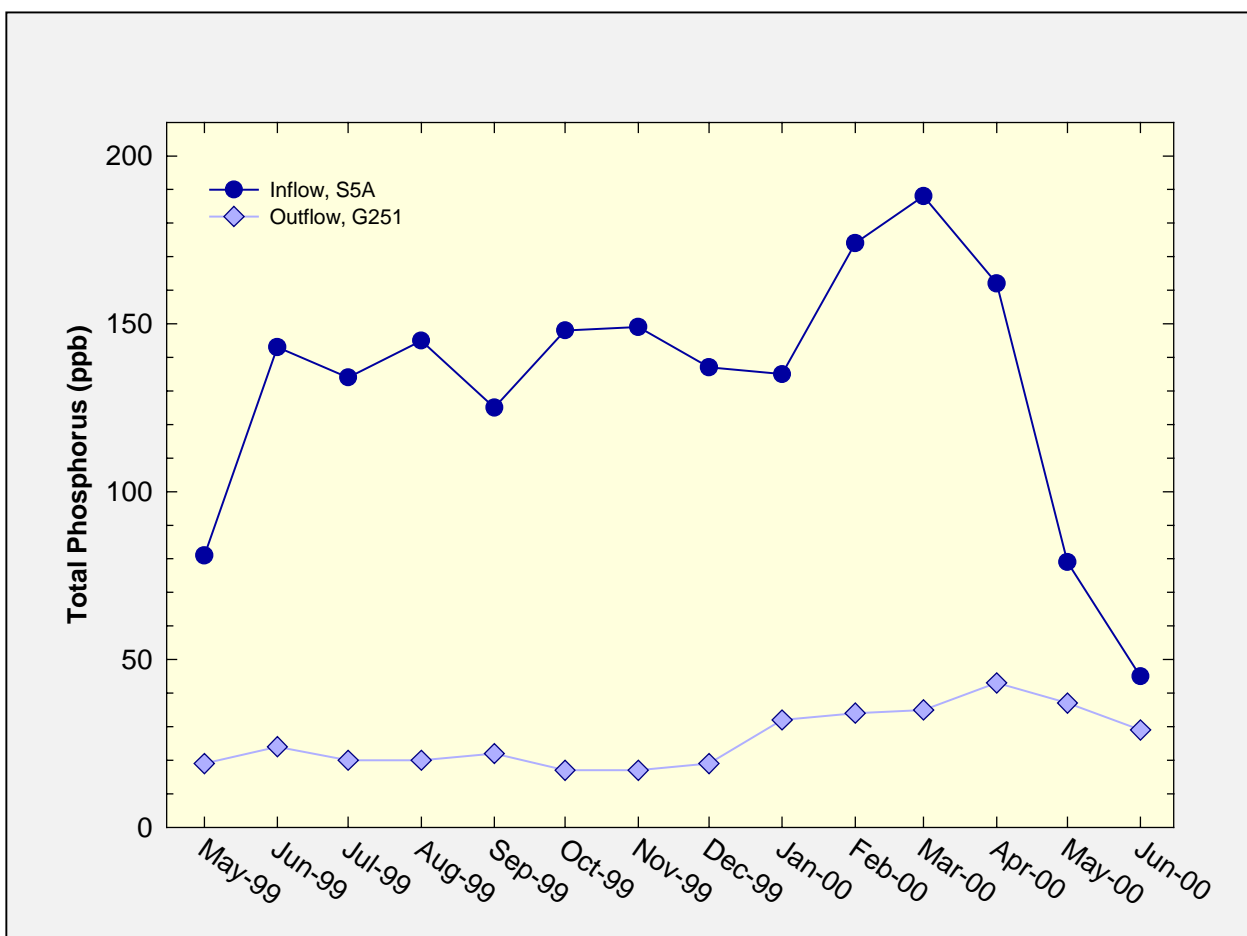
### Phosphorus Loads and Concentrations

Total phosphorus loads from STA-1W were reduced by 92 percent in April, 76 percent in May and 85 percent in June 2000 (**Figure 11a**). **Figure 11a** displays monthly load reductions starting with May 1999 when the STA-1W permit went into effect. The 12-month reduction and the target reduction of 75 percent are no longer displayed because neither is still required in the STA-1W permit. During the second quarter of 2000, 9.46 metric tons of total phosphorus moved through S5A compared with 1.16 metric tons discharged from the outflow of STA-1W (G251) (**Figure 11b**).

The monthly average flow-weighted mean total phosphorus concentrations of S5A were 162, 79 and 45 ppb for April, May and June, respectively (**Figure 12**). The flow-weighted mean concentrations in the outflows (G251) were 43, 37, and 29 ppb for the same three months.



**Figure 11.** a. Monthly percent reduction of total phosphorus in STA-1W.  
b. Monthly total phosphorus loads at inflow and outflow sites of STA-1W.



**Figure 12.** Monthly flow-weighted mean total phosphorus concentrations at inflow and outflow sites of STA-1W.

## Mercury Concentrations

The STA-1W permit requires the District to collect unfiltered water samples quarterly for analysis of total mercury (THg) and methylmercury (MeHg). Samples are collected at the inflow and at each of the two outflow structures. The permit also requires the District to collect between 100 and 250 mosquitofish (*Gambusia holbrooki*) semiannually and 20 largemouth bass (*Micropterus salmoides*) annually. The fish are collected from the inflow, interior marshes and outflows for mercury analysis. Individual mosquitofish are pooled to form composite samples for each location. In 2000, sunfish (*Lepomis spp.*) were added to this monitoring program to better evaluate mercury exposure to fish-eating birds.

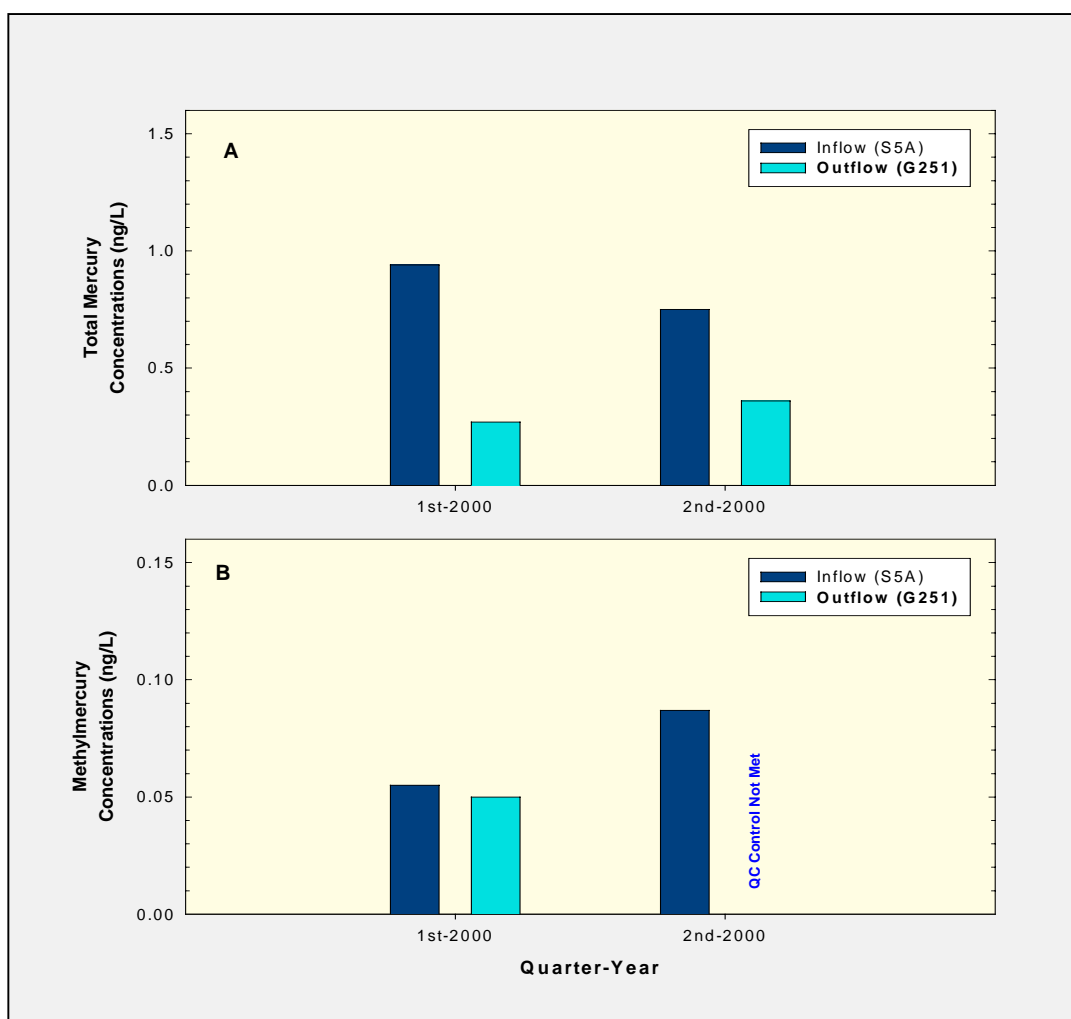
Monitoring mercury concentrations in aquatic plants and animals (biota) provides several advantages. First, MeHg occurs at much greater concentration in biota relative to surrounding water, making chemical analysis more accurate and precise. Although detection levels of part per trillion (ppt or ng/L) have been achieved for THg and MeHg in water, uncertainty boundaries can become large when ambient concentrations are very low, as is often the case in the Everglades. Second, organisms integrate exposure to mercury over space and time. Since mosquitofish are short lived, they can be used to monitor short-term changes in environmental concentrations of mercury through time. In the case of largemouth bass and sunfish, they are long-lived species and represent average conditions that occurred over previous years. Finally, the mercury concentration in biota is a true measure of MeHg bioavailability and results in a better indicator of possible exposure to fish-eating wildlife than the concentration of mercury.

Sampling for mercury in STA1W started on February 16, 2000. Surface water samples for the second quarter of 2000 were collected May 25. At the time these samples were collected, construction of the second outflow pump, G310, was not yet complete. Therefore, all outflow was through G251. THg concentrations at the inflow and outflow were 0.75 and 0.36 ng/L, respectively (**Figure 13a**). MeHg concentrations at the inflow and outflow were 0.09 and 0.1 ng/L, respectively (**Figure 13b**). However, the sample collected at the outflow for MeHg failed to meet the District's quality control criterion for precision and is only an estimate.

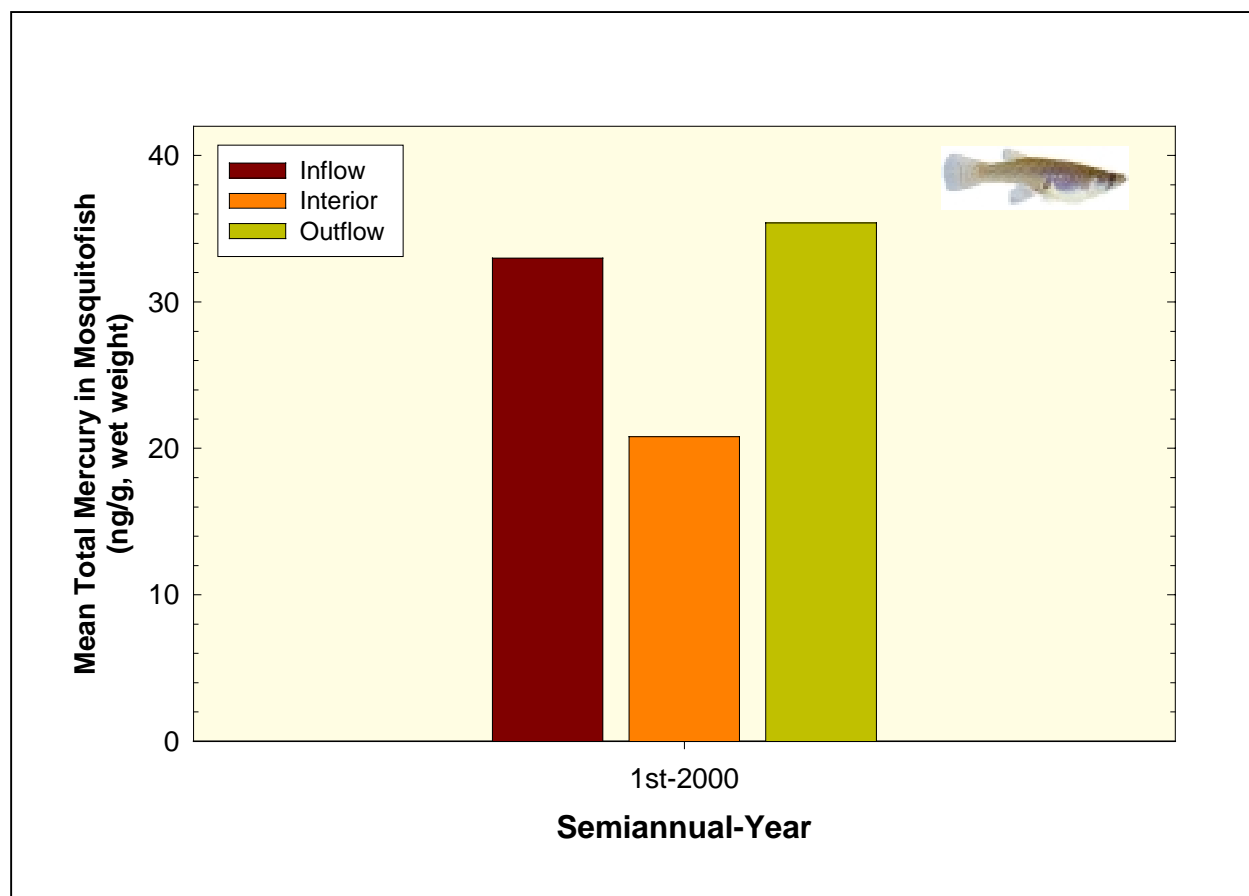
Concentrations of both unfiltered THg and MeHg were within the typical range previously measured in this area when it was operated as the Everglades Nutrient Removal Project (note, the inflow station has moved from ENR002 to S5A). THg concentrations in the inflow and outflow were both below Florida's Class III Water Quality Standard of 12 ng/L.

Results from the annual collections of largemouth bass and sunfish are reported in the draft [\*2001 Everglades Consolidated\*](#)

*Report* (SFWMD, 2001). The first collection of mosquitofish occurred March 29, 2000. At that time, tissue mercury concentrations were 33 ng/g wet weight in fish at the inflow,  $20.8 \pm 13.6$  ng/g in fish from interior marshes (mean  $\pm$  1 standard error of composites from three Cells) and, 35.4 ng/g in fish at the outflow (**Figure 14**). Considering the inherent analytical variability, as shown by replicate analyses of the same composite sample, concentrations observed in fish from the inflow did not differ from levels observed at the outflow. The concentrations of mercury in fish tissues were well below guidance levels suggested by both the U.S. Fish and Wildlife Service (USFWS; 100 ng/g) and the U.S. Environmental Protection Agency (U.S. EPA; 77 ng/g) for the protection of fish-eating avian and mammalian wildlife.



**Figure 13.** a. Quarterly surface water total mercury concentrations at inflow and outflow sites of STA-1W. b. Quarterly surface water methylmercury concentrations at inflow and outflow sites of STA-1W.



**Figure 14.** Mean total mercury concentrations in mosquitofish collected at the inflow, interior and outflow of STA-1W.

# HOLEY LAND

## SUMMARY

## MAP

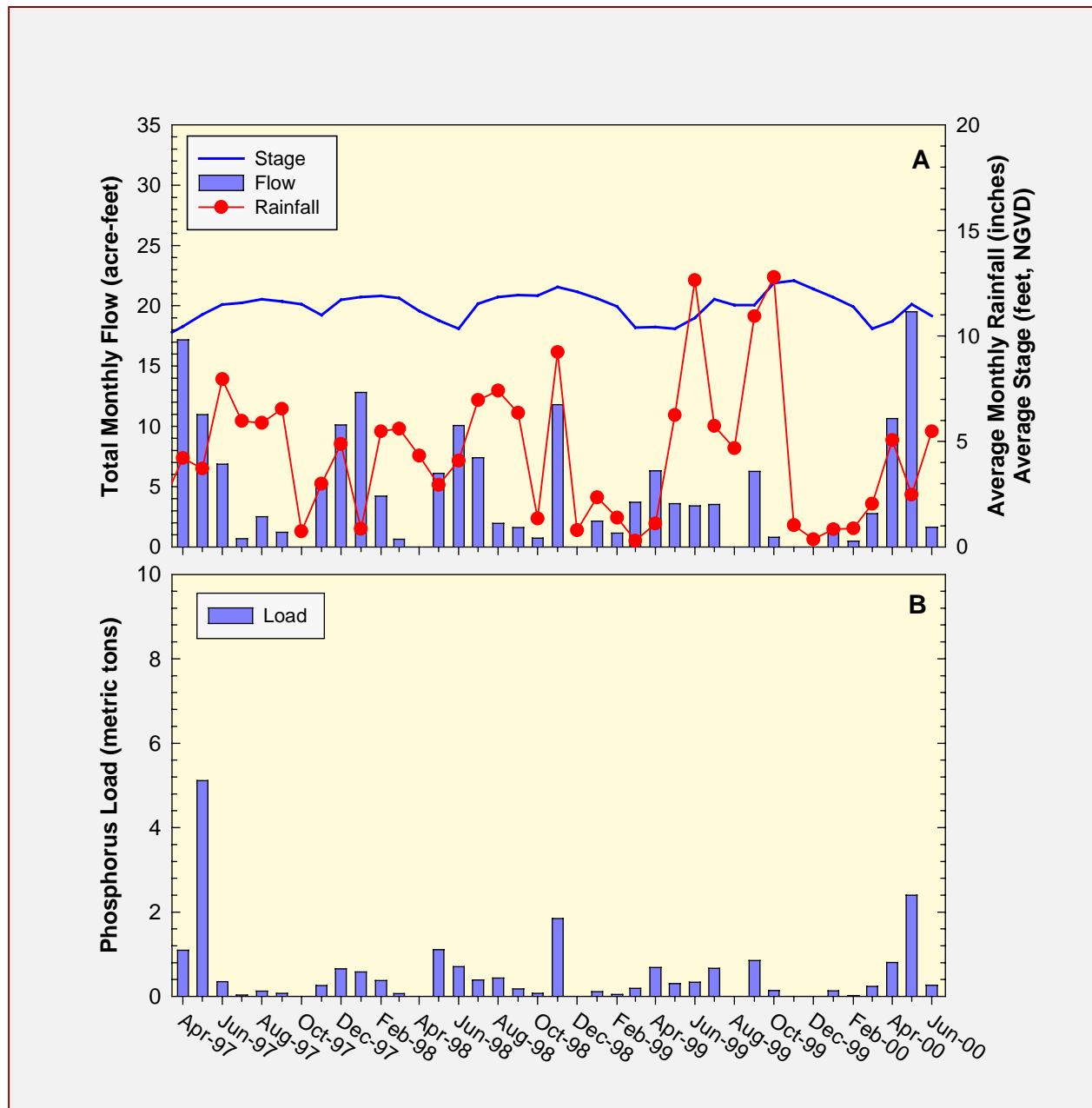
The Holey Land Management Area (Holey Land) is a 35,000-acre tract of land that is operated as a wildlife management area by the Florida Fish and Wildlife Conservation Commission (FFWCC). A Memorandum of Agreement between the Florida Department of Environmental Protection (FDEP), the Board of Trustees of the Internal Improvement Trust Fund, the FFWCC and the South Florida Water Management District established an environmental restoration plan for the Holey Land. As part of the restoration plan, water quality monitoring was implemented to meet the requirements of FDEP Permit No. 06-500809209.

Water quality monitoring is conducted at six surface water inflow and outflow structures as shown in the map ([click link above to view map](#)). Nutrient inputs to the Holey Land can occur through surface water inflows from the Miami Canal (G200) and seepage return pumps (G200SD and G201).

## Hydrology

The restoration effort also includes an operational plan schedule for maintaining surface water levels (schedule) within the Holey Land. During the wet season from May 15 through October 31, the schedule rises linearly from approximately 10.5 feet National Geodetic Vertical Datum (NGVD) to 12 feet NGVD. During the dry season from November 1 through May 14, the schedule declines linearly from 12 feet NGVD to 10.5 feet NGVD. Prior to 1996, the schedule was maintained between 11.5 feet and 13.5 feet NGVD. During wet years when sufficient rainfall can maintain the stage in the Holey Land according to schedule, less surface water inflow from the Miami Canal is required. The restoration plan requires the outflow structures (G204, G205 and G206) to be closed. However, unregulated flows from the outflow structures occur through seepage.

**Figure 15a** demonstrates the relationship between rainfall and average stage level in the Holey Land, and inflows from the Miami Canal (G200) for the period from April 1997 through June 2000. Also shown in **Figure 15a** are monthly flows into the management area. The increased flows for April and May coincide with the regulated releases of water during the lowering of Lake Okeechobee.



**Figure 15.** a. Flow, rainfall and stage measured at inflow station G200.  
b. Phosphorus loads discharged into the Holey Land at inflow station G200.

## Phosphorus Loads

Monthly phosphorus loads calculated for inflow site G200 are presented in **Figure 15b**. During the second quarter of 2000, 3.5 metric tons of phosphorus entered the Holey Land through G200. Phosphorus loads for April, May and June were 0.8, 2.4 and 0.3 metric tons, respectively. The highest phosphorus load for this period was observed in May and coincides with the highest flow recorded.

The mean monthly load of phosphorus from April 1997 through June 2000 remained approximately 0.5 metric tons. (**Figure 15b**). Approximately three times more phosphorus entered into the Holey Land during the second quarter of 2000 than during the same period for the previous year.

## Phosphorus Concentrations

**Figure 16** displays total phosphorus concentrations collected from April 1997 through June 2000 by grab and composite sampling at inflow station G200. Grab samples have been collected at G200 since July 1989, while composite samples have been collected at this site since March 1996.

The total phosphorus concentration for grab samples collected at G200 for the reporting period April 1997 through June 2000 averaged 57 parts per billion (ppb). Composite samples have exhibited an average total phosphorus concentration of 85 ppb during this period.

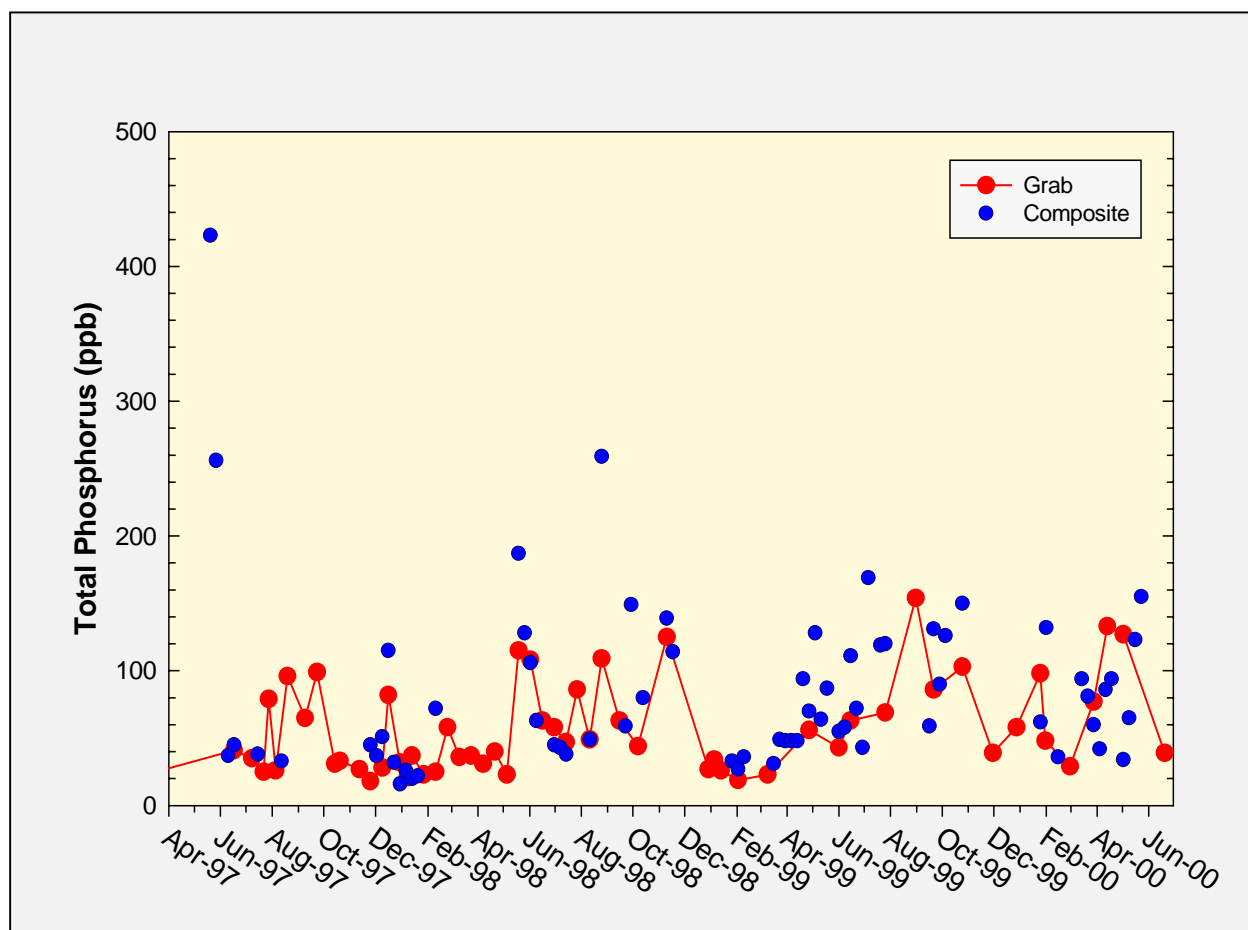
Total phosphorus concentrations averaged 100 ppb for grab samples and 86 ppb in composite samples collected during the second quarter of 2000. Compared with the second quarter of the previous year, total phosphorus concentrations for the present reporting period were 125 percent higher for both the grab and composite samples.

**Figure 17** provides the quarterly total phosphorus levels collected at stations G204, G205 and G206. Grab sample data for these outflow stations are presented from the first quarter in 1997 through the second quarter of 2000.

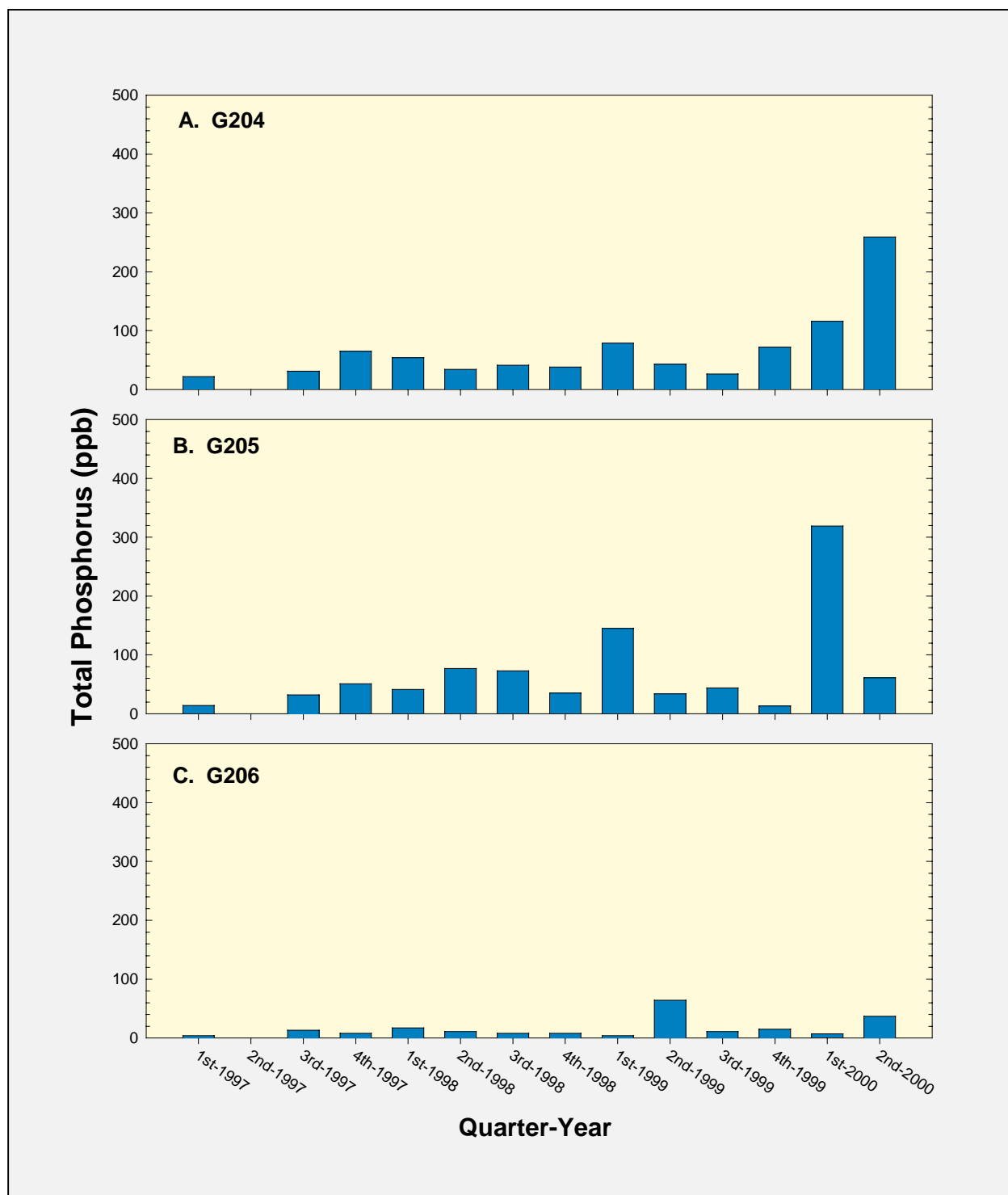
A gradient in the total phosphorus concentration is evident for the three outflow stations. Phosphorus concentrations at G204 and G205 are generally higher than those at G206 (**Figure 17**). Historically, total phosphorus concentrations at G204 and G205 have averaged approximately 70 ppb compared to 16 ppb at G206. The lower total phosphorus concentrations reported for G206 might result from dilution with water from the adjacent seepage canal where the phosphorus content is lower than in the management area. The canal water is pumped into the Holey Land from seepage return pump stations G200SD and G201. Total phosphorus

concentrations measured at G201 and G200SD averaged 10 ppb and 15 ppb, respectively.

Total phosphorus concentrations measured at G201 and G200SD averaged 12 ppb and 19 ppb, respectively.



**Figure 16.** Total phosphorus concentrations for grab and composite samples collected at G200



**Figure 17.** Quarterly total phosphorus concentrations measured for grab samples collected at outflow stations a. G204, b. G205 and c. G206.

# STORMWATER TREATMENT AREA 6

## SUMMARY

## MAP

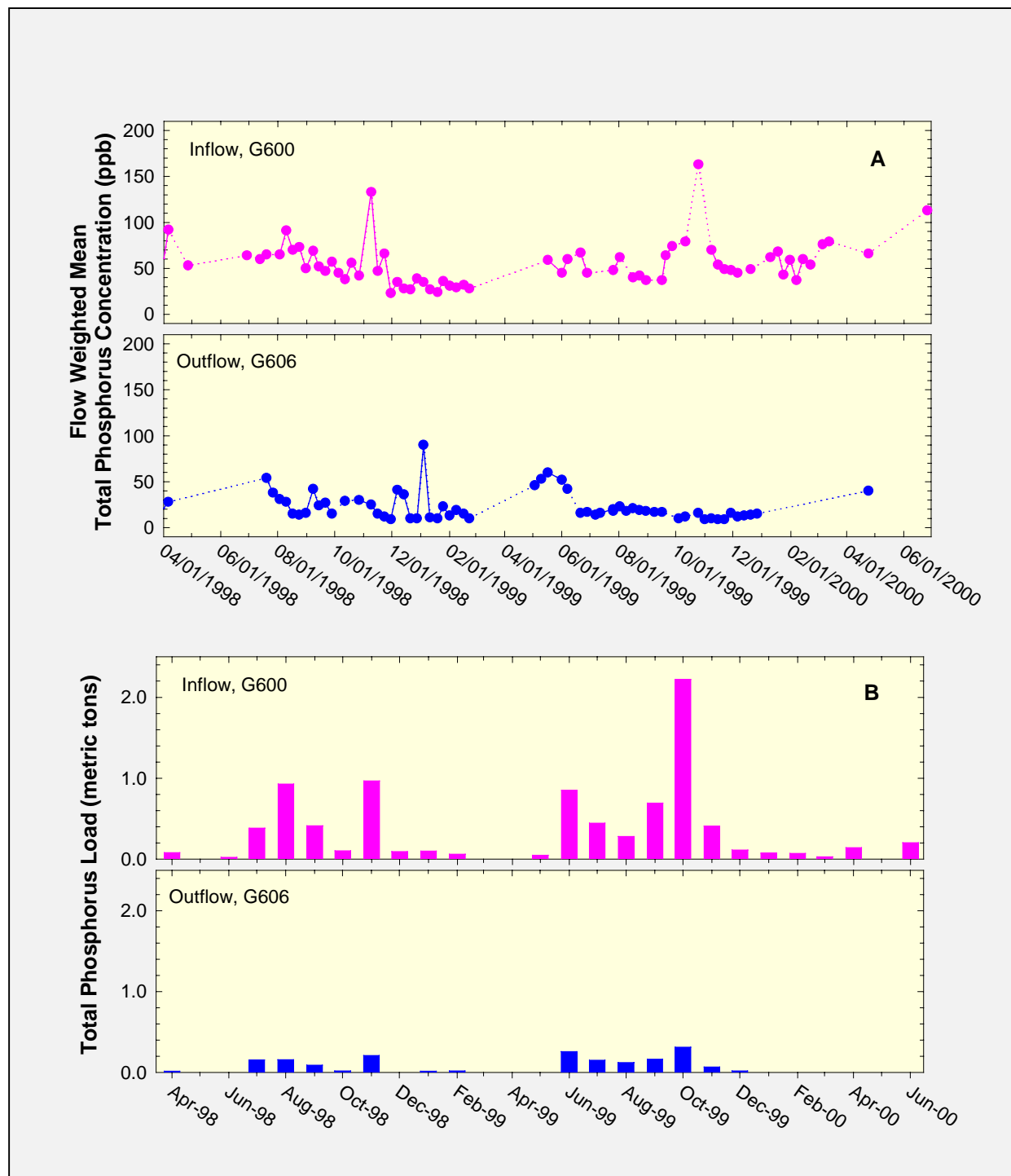
Stormwater Treatment Area 6 (STA-6), Section 1, began full operation on December 9, 1997. It occupies an existing detention area associated with United States Sugar Corporation's (USSC) Southern Division Ranch, Unit 2 development, except for 1 acre, which is within the adjacent Rotenberger Tract. STA-6 provides a total effective treatment area of approximately 870 acres. The source of water for STA-6 comes solely from USSC's Unit 2 pump station G600. The lowering of Lake Okeechobee, which occurred during the second quarter of 2000, had no apparent effect on STA-6.

## Phosphorus Concentrations

For the second quarter of 2000, the flow-weighted mean total phosphorus concentrations at the inflow averaged 92.5 ppb and 40 ppb at the outflow. Due to low rainfall during the second quarter, there were only two samples collected at the inflow site (one in April and one in June), and only one sample collected at the outflow site, in April. The average flow-weighted mean total phosphorus concentration for the period of record at the outflow is 20 ppb, or three times lower than the average inflow concentration (**Figure 18a**).

## Phosphorus Loads

Phosphorous loads were only calculated for the two samples mentioned above at the inflow site. They were 0.139 metric tons in April and 0.203 metric tons in June (**Figure 18b**). At the outflow site the load was 0.002 metric tons for the one sample collected in April (**Figure 18b**). The total phosphorus load reduction for the second quarter of 2000 was 99 percent due to the lack of discharge from STA-6. The overall total phosphorus load has been reduced by 78 percent since the project began in December 1997.



**Figure 18.** a. Weekly flow-weighted mean total phosphorus concentrations at inflow and outflow sites of STA-6, Section 1. b. Monthly total phosphorus load at inflow and outflow sites of STA-6, Section 1.

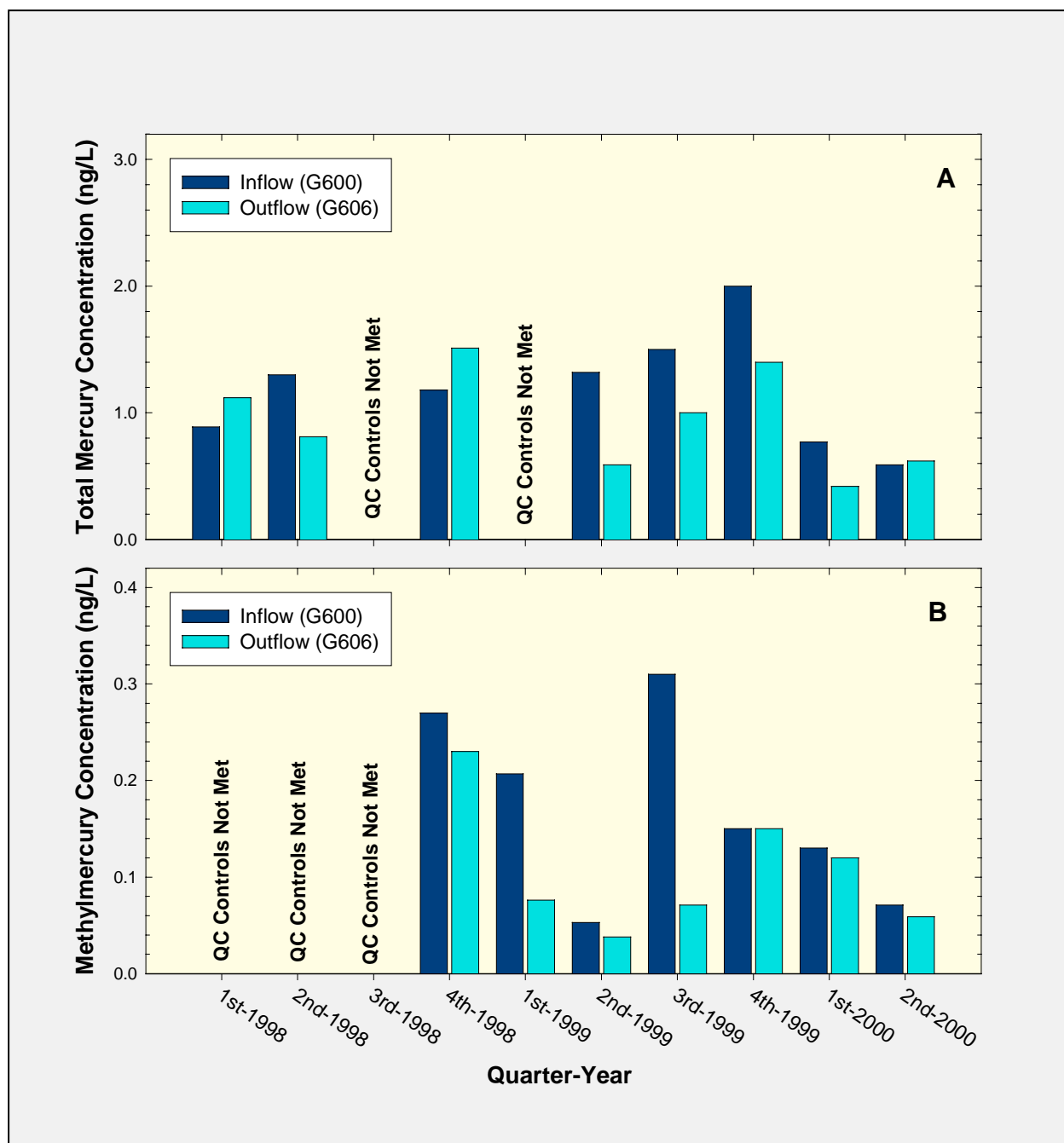
## Mercury Concentrations

The STA-6, Section 1 permit requires the District to collect unfiltered water samples quarterly for analysis of total mercury (THg) and methylmercury (MeHg). Samples are collected in the Supply Canal near the inflow and from the Discharge Canal near the outflow structures. The permit also requires the District to collect between 100 and 250 mosquitofish (*Gambusia holbrooki*) semi-annually and 20 largemouth bass (*Micropterus salmoides*) annually from the inflow, interior marsh and outflow for mercury analysis. Individual mosquitofish are pooled to form composite samples for each location. In 2000, sunfish (*Lepomis spp.*) were added to this monitoring program to better evaluate mercury exposure to fish-eating birds.

Monitoring mercury concentrations in aquatic plants and animals (biota) provides several advantages. First, MeHg occurs at much greater concentration in biota relative to surrounding water, which makes chemical analysis more accurate and precise. Although detection levels of part per trillion (ppt or ng/L) have been achieved for THg and MeHg in water, uncertainty boundaries can become large when ambient concentrations are very low, as is often the case in the Everglades. Second, organisms integrate exposure to mercury over space and time. As mosquitofish are short lived, they can be used to monitor short-term changes in environmental concentrations of mercury through time. In the case of largemouth bass and sunfish, they are long-lived species and represent average conditions that occurred over the previous year. Finally, the mercury concentration in biota is a true measure of MeHg bioavailability and results in a better indicator of possible exposure to fish-eating wildlife than the concentration of mercury in the surrounding water, sediment or vegetation.

Sampling for mercury started in the first quarter of 1998. Samples for the second quarter of 2000 were collected June 12. At that time, THg concentrations in the inflow and outflow were 0.59 and 0.62 ng/L, respectively (**Figure 19a**). MeHg concentrations in the inflow and the outflow were 0.07 and 0.06 ng/L, respectively (**Figure 19b**).

With the exception of a small discharge that occurred during April 19-20 (<20 cfs), there has been no appreciable flow from either Cell 3 or Cell 5 since December 28, 1999. In fact, STA-6 went dry from March 8 through April 16, 2000. A second drydown began on May 18 and continued until June 28. Because of low rainfall from March through June 2000, United States Sugar Corporation (USSC), which operates the pump station at G600, frequently backpumped water for irrigation of the Unit 2 farm located adjacent to STA-6. During backpumping, water is conveyed from the L-4 canal backward through the Supply Canal using stop logs at G604. During backpumping of the L-4 canal, water can also

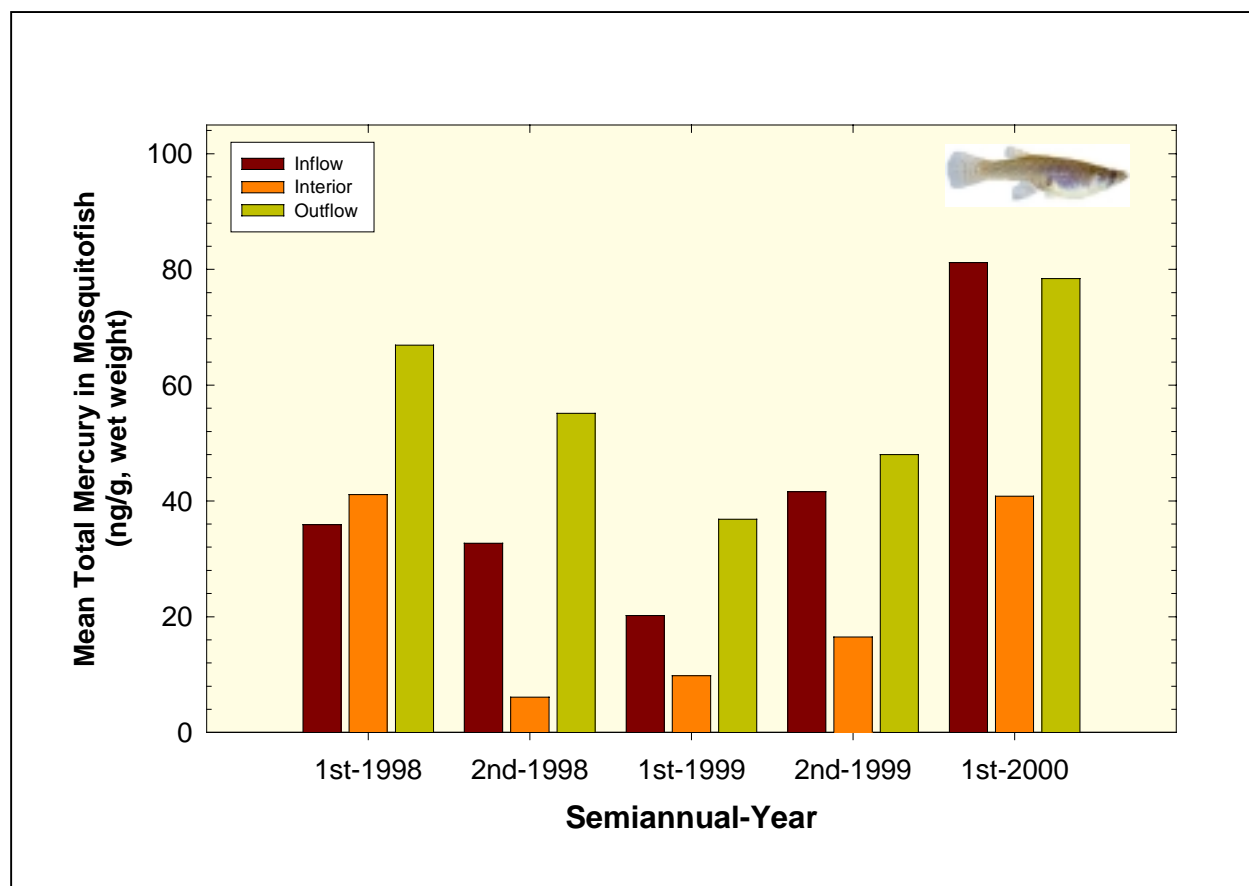


**Figure 19.** a. Quarterly surface water total mercury concentrations at inflow and outflow sites of STA-6. b. Quarterly surface water methylmercury concentrations at inflow and outflow sites of STA-6.

flow up and into the Discharge Canal. Consequently, at the time that the samples were collected, conditions in the Discharge Canal did not reflect the influence of discharge water from the STA, but rather water from the L-4 Canal. Nevertheless, observed concentrations of THg were below Florida's Class III Water Quality Standard of 12 ng/L.

Results from the annual collections of largemouth bass and sunfish are reported in the District's *2001 Everglades Consolidated Report, Chapter 7*. Mosquitofish were first collected at STA-6 in early 1998. Because STA-6 was dry in March 2000, when the first collection attempt was made, the first semiannual sampling event for mosquitofish for the current year did not occur until June 7. At that time, tissue mercury concentrations were 81 ng/g in fish from the inflow, 41 ng/g in fish from an interior marsh and, 78 ng/g in fish from the Discharge Canal (**Figure 20**). However, as already discussed, there had been no appreciable discharge from the STA for six months and, thus, conditions in the Discharge Canal did not reflect flow from the STA. Alternatively, tissue mercury concentrations in fish from the interior marsh did reflect STA-6 conditions, especially the drydowns. The mosquitofish sampled from the marsh June 7, during the second drydown (see above), were collected by walking 500 meters out into Cell 5 to a small pool of water. Drydowns with subsequent exposure and oxidation of sediments have been found to alter sediment (and porewater) chemistry influencing mercury biogeochemistry and increasing its availability for bioaccumulation. As a result, mercury levels in fish from the interior marsh did not accurately reflect typical operation of an STA.

Levels of mercury in mosquitofish from the inflow and outflow approached or just exceeded guidance levels suggested by the U.S. Fish and Wildlife Service (USFWS; 100 ng/g) and the U.S. Environmental Protection Agency (U.S. EPA; 77 ng/g) for the protection of fish-eating avian and mammalian wildlife. Tissue concentrations of mercury in mosquitofish from the interior remained below these guidance levels.



**Figure 20.** Mean total mercury concentrations in mosquitofish collected at the inflow, interior and outflow of STA-6.

# LOXAHATCHEE NATIONAL WILDLIFE REFUGE

## SUMMARY

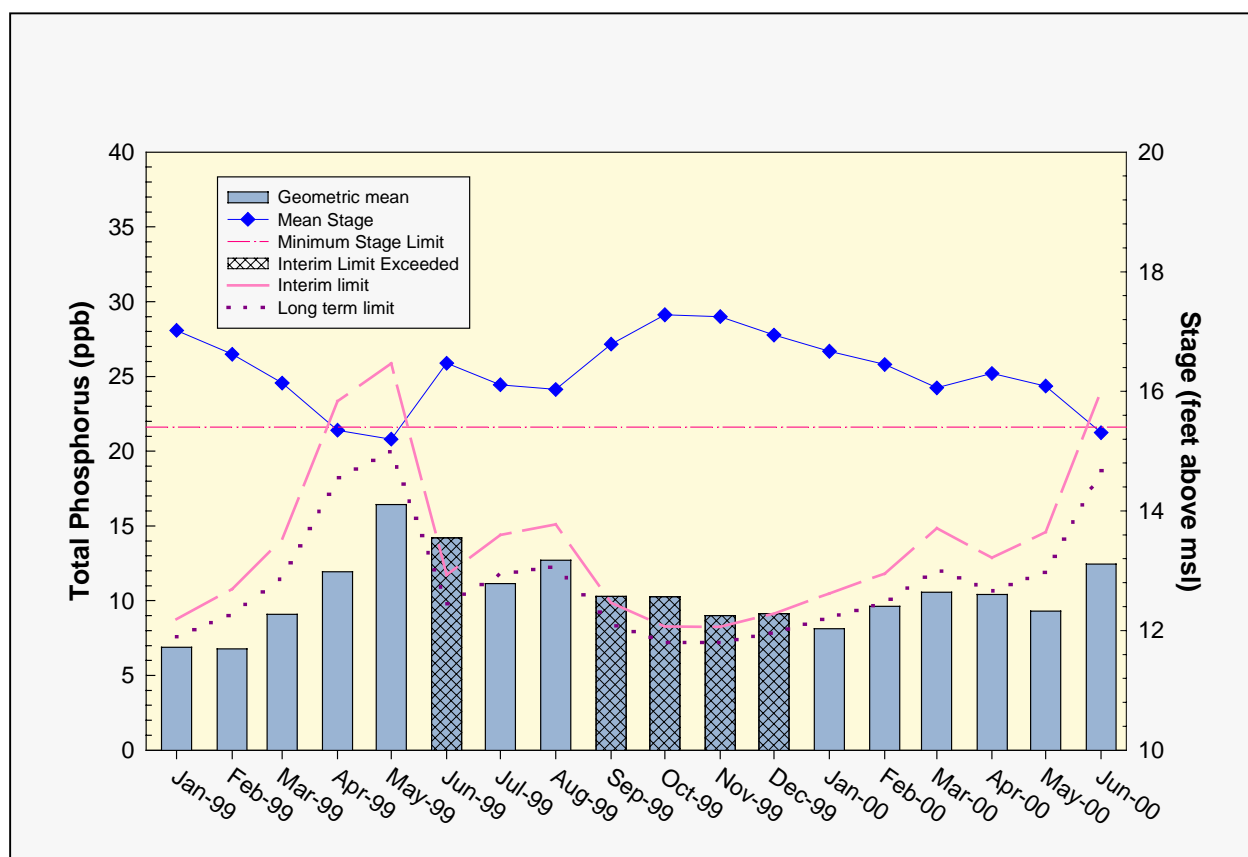
## MAP

### Phosphorus Concentrations

The Settlement Agreement entered into by the federal government, the State of Florida and the South Florida Water Management District in 1991 to end the Everglades lawsuit stipulates interim and long-term phosphorus concentration levels for the Arthur R. Marshall Loxahatchee National Wildlife Refuge (Refuge). The interim and long-term concentration levels must be met by Feb. 1, 1999, and Dec. 31, 2006, respectively. The concentration levels vary monthly because they are calculated as a function of water level measured at gaging stations 1-7, 1-8C and 1-9 within the Refuge. Total phosphorus concentrations are determined from water samples collected at the 14 interior marsh stations (LOX 3 through LOX 16) shown on the map.

Average stages in the Refuge were 16.30 feet in April, 16.09 feet in May and 15.31 feet in June. As indicated in **Figure 21**, the stages in April and May were about 0.5 feet higher than would have been expected due to water from Lake Okeechobee entering the Refuge through structures G300 and G301 from May 3 to May 13. Water was released from the Refuge through G300 from May 23 to June 8 and intermittently from G301 from June 16 until June 25. These water releases resulted in decreasing stages in the Refuge to the extent that only 11 stations were sampled in May and six stations in June.

The geometric means calculated from total phosphorus concentrations measured in water samples collected in April, May and June 2000 were 10.4, 9.1 and 12.4 ppb, respectively. These geometric mean concentrations were less than the calculated interim and long-term limits for each respective month (**Figure 21**). The interim limits for April and May were 12.9 and 14.6 ppb, respectively, while the long-term limits for these same months were 10.6 and 11.9 ppb, respectively. The interim and long-term limits for June do not apply since the equation for calculating the limits is not applicable when the average stage is less than 15.42 feet. There did not appear to be any detectable influence on water quality within the Refuge from lowering Lake Okeechobee.



**Figure 21.** Monthly total phosphorus geometric mean concentration levels for the Arthur R. Marshall Loxahatchee National Wildlife Refuge compared to the interim and long-term targets. The calculated target concentrations are adjusted for fluctuations in water level.

# EVERGLADES NATIONAL PARK

## SUMMARY

## MAP

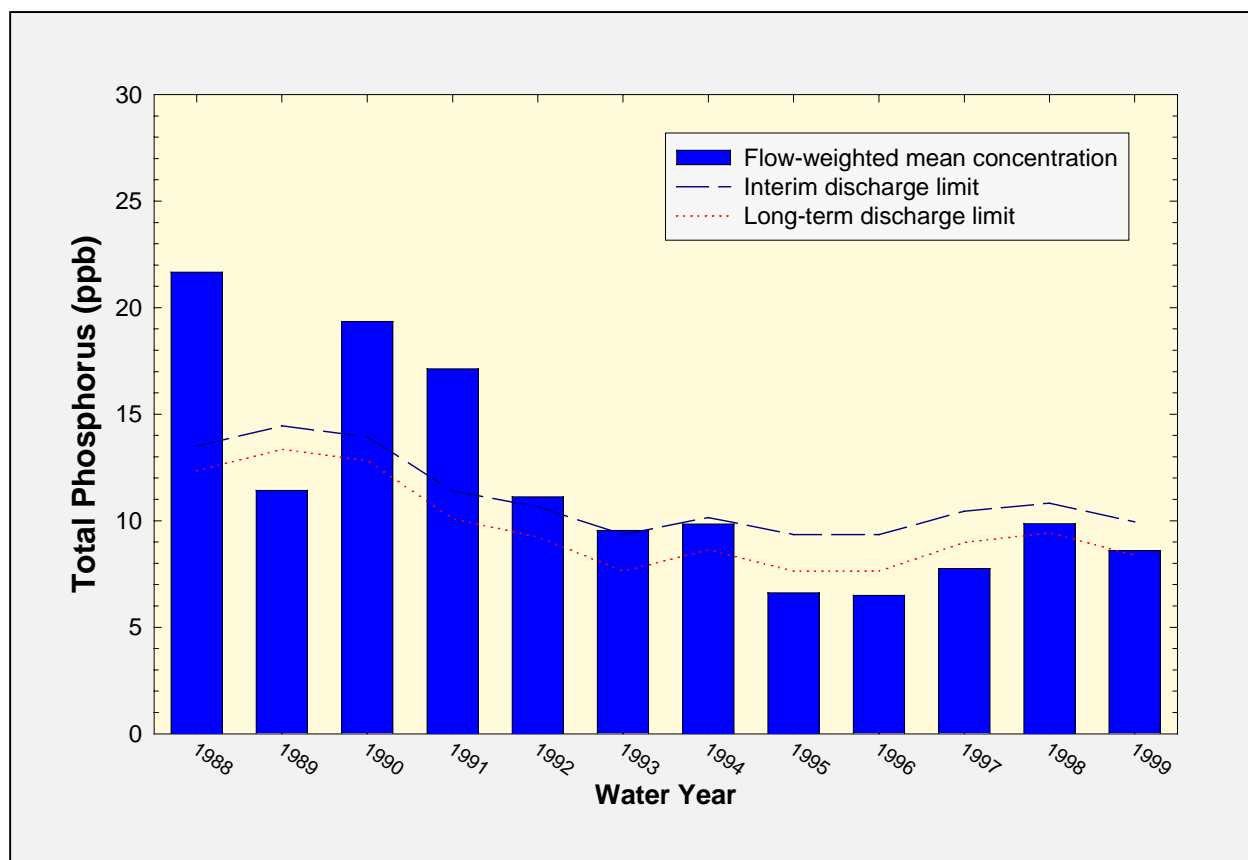
### Shark River Slough

The Settlement Agreement of 1991 set separate interim and long-term total phosphorus concentration limits for discharges into the Everglades National Park through Shark River Slough to be met by October 1, 2003, and December 31, 2006, respectively. The limits apply to the water year ending September 30. The long-term total phosphorus concentration limit for inflows to Shark River Slough through structures S12A, S12B, S12C, S12D and S333 represents the concentrations delivered during the Outstanding Florida Waters baseline period of March 1, 1978, to March 1, 1979, and is adjusted for variations in flow. In addition, the Settlement Agreement requires that phosphorus concentrations be presented as 12-month moving flow-weighted means.

Inflow concentrations of total phosphorus through Shark River Slough are compared to the interim and long-term limits at the end of each water year (**Figure 22**). The 12-month moving flow-weighted mean total phosphorus concentration ending September 1999 was 9.5 ppb. Corresponding interim and long-term limits were 9.8 and 8.2 ppb, respectively.

**Table 5** presents the moving flow-weighted mean concentrations for each 12-month period beginning with water year 1998 as well as the corresponding interim and long-term total phosphorus concentration limits. The limits are calculated using the 12-month period flow. For the 12-month periods ending in April, May and June 2000, the flow-weighted mean total phosphorus concentrations were 9.1, 9.6 and 9.8 ppb, respectively. The April value was less than the interim limit of 9.4, but the May and June values were greater than the 9.4 ppb interim limit. All three months were above the long-term limit of 7.6 ppb.

The Settlement Agreement stipulates that the percent of flow-weighted mean total phosphorus concentrations greater than 10 ppb from each sampling event in any 12-month period must not exceed an allowable value based on flow into Shark River Slough for the same 12-month period. For the 12-month periods ending in



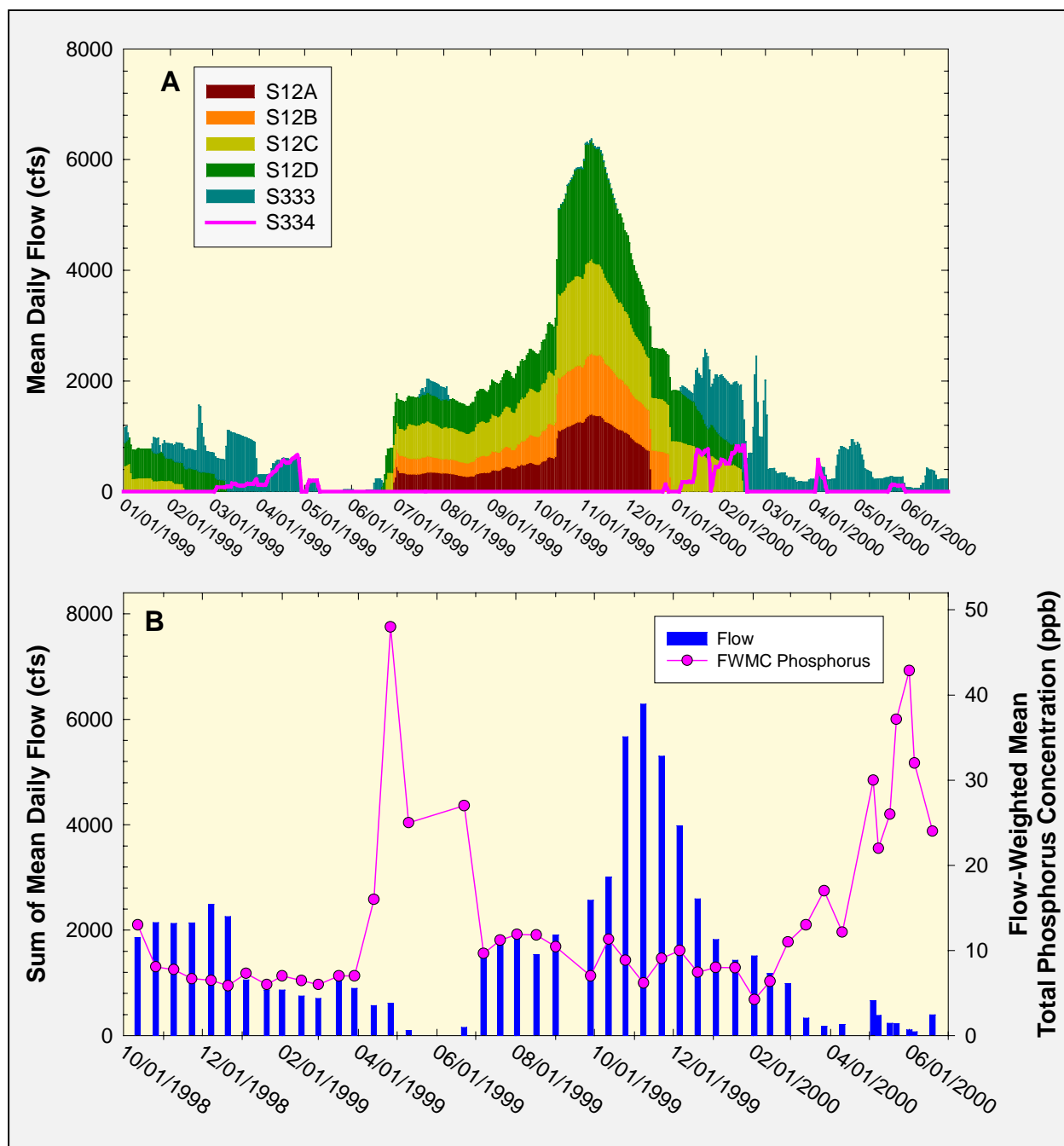
**Figure 22.** 12-month moving flow-weighted mean total phosphorus concentrations at the end of each water year in inflows to Everglades National Park (ENP) through Shark River Slough compared to the interim and long-term targets.

April, May and June 2000, the percent of flow-weighted mean total phosphorus concentrations greater than 10 ppb was 59.1, 64.0 and 66.7 for April, May and June, respectively. These percentages exceeded the allowable limit of 40.1 percent for all three periods (Table 5).

The daily mean flows through the individual Shark River Slough structures and S334 from October 1998 through June 2000 are presented in **Figure 23a**. As indicated in **Figure 23a**, all flow in April, May and June entered northeastern Shark River Slough through S333. The relationship between the sum of the daily mean flows at Shark River Slough structures and the corresponding flow-weighted mean total phosphorus concentrations for individual sampling events is presented in **Figure 23b**. The total phosphorus concentrations in samples collected at S333 in May and June 2000 ranged from 22 to 44 ppb (**Figure 23b**). The normal range of total phosphorus concentrations at S333 is from 6 to less than 20 ppb. The higher concentrations in May and June reflected water released from Lake Okeechobee as the lake was being lowered.

**Table 5. Shark River Slough Total Phosphorus Compliance Tracking.**

12-Month Period Ending On	Total Period Flow (ac-ft x 10 <sup>3</sup> )	Flow Weighted Mean Total Phosphorus (ppb)	Limits (ppb)		Percent of Samples Greater Than 10 ppb (%)	
			Interim	Long Term	Observed	Allowed
09/30/1998	737.6	9.8	10.7	9.2	48.2	48.1
10/31/1998	728.2	10.4	10.7	9.3	48.2	48.3
11/30/1998	772.4	10.3	10.5	9.1	48.2	47.1
12/31/1998	871.4	9.7	10.1	8.6	46.4	44.5
01/31/1999	852.7	9.4	10.2	8.7	42.9	45.0
02/28/1999	842.9	9.3	10.2	8.7	44.4	45.3
03/31/1999	826.7	9.1	10.3	8.8	40.7	45.7
04/30/1999	750.3	9.9	10.6	9.2	48.2	47.7
05/31/1999	674.6	9.8	11.0	9.6	48.0	49.9
06/30/1999	680.2	9.6	10.9	9.6	40.9	49.7
07/31/1999	788.4	9.7	10.4	9.0	45.8	46.7
08/31/1999	857.6	9.6	10.1	8.6	43.5	44.9
09/30/1999	939.9	9.5	9.8	8.2	43.5	42.9
10/31/1999	1,084	9.4	9.4	7.6	47.8	40.1
11/30/1999	1,298	9.1	9.4	7.6	47.8	40.1
12/31/1999	1,345	9.4	9.4	7.6	47.8	40.1
01/31/2000	1,395	9.4	9.4	7.6	47.8	40.1
02/29/2000	1,415	9.4	9.4	7.6	50.0	40.1
03/31/2000	1,386	9.6	9.4	7.6	60.9	40.1
04/30/2000	1,385	9.1	9.4	7.6	59.1	40.1
05/31/2000	1,401	9.6	9.4	7.6	64.0	40.1
06/30/2000	1,396	9.8	9.4	7.6	66.7	40.1



**Figure 23.** a. Mean daily flows into Shark River Slough by structure. b. The relationship between sum of mean daily flow at Shark River Slough structures and flow-weighted mean total phosphorus concentration for individual sampling events.

## Taylor Slough and The Coastal Basins

Under the Settlement Agreement, a single total phosphorus long-term limit of 11 ppb, to be met by December 31, 2006, was set for the two points of inflow to Taylor Slough (S332 and S175) and the inflow point to the Coastal Basins (S18C). The 11 ppb limit applies to the water year ending September 30. Beginning in August 1999, structure S332D, a new pump station constructed by the U.S. Army Corps of Engineers, began operation. The structure is adjacent to spillway S174 and pumps water from the L31N canal into the L31W canal. The S332D and S174 structures became the new inflow compliance monitoring sites for Taylor Slough on October 1, 1999, replacing S332 and S175. However, the Settlement Agreement's Technical Oversight Committee requested that data from both the old and new pairs of inflow structures to Taylor Slough be presented for one year. This request was made to determine if the differences between the two data sets observed from August 1999 through March 2000 would continue throughout a complete wet season/dry season cycle and what implications this might have on future compliance with the 11 ppb limit.

Inflow concentrations of total phosphorus to the Everglades National Park through Taylor Slough and the Coastal Basins are compared to the 11 ppb limit at the end of each water year using data from both the old (S175, S332, S18C) and new (S174, S332D, S18C) combinations of structures for the 1999 water year (**Figure 24a**). The bars in **Figure 24a** represent the flow-weighted mean total phosphorus concentrations from S332, S175 and S18C for water years 1988 through 1999. The diamond point value for water year 1999 represents the flow-weighted mean total phosphorus concentration for S174 and S18C from October 1, 1998, through September 30, 1999, plus the S332D data from August 30, 1999, through September 30, 1999.

**Figure 24b** presents the 12-month moving average and individual sampling event flow-weighted mean total phosphorus concentrations at both the old and new combinations of structures. The moving average for the new combination has been consistently greater than the moving average for the old combination. This difference is attributed to seepage into the L31W canal downstream of S174 and S332D. Seepage increases flow in the L31W canal and also dilutes the total phosphorus concentrations by the time the water reaches the S332 and S175 discharge structures (**Figure 24a** and **Table 6**).

The 12-month flow-weighted mean concentrations for April, May and June 2000 were 9.0 ppb for all three months at the new combination of structures and 7.9, 8.0 and 7.9 ppb for April, May and June, respectively, for the old combination of structures (**Table 6**). The Settlement Agreement stipulates that the percent of flow-weighted mean total phosphorus concentrations greater than 10 ppb from each sampling event in any 12-month period

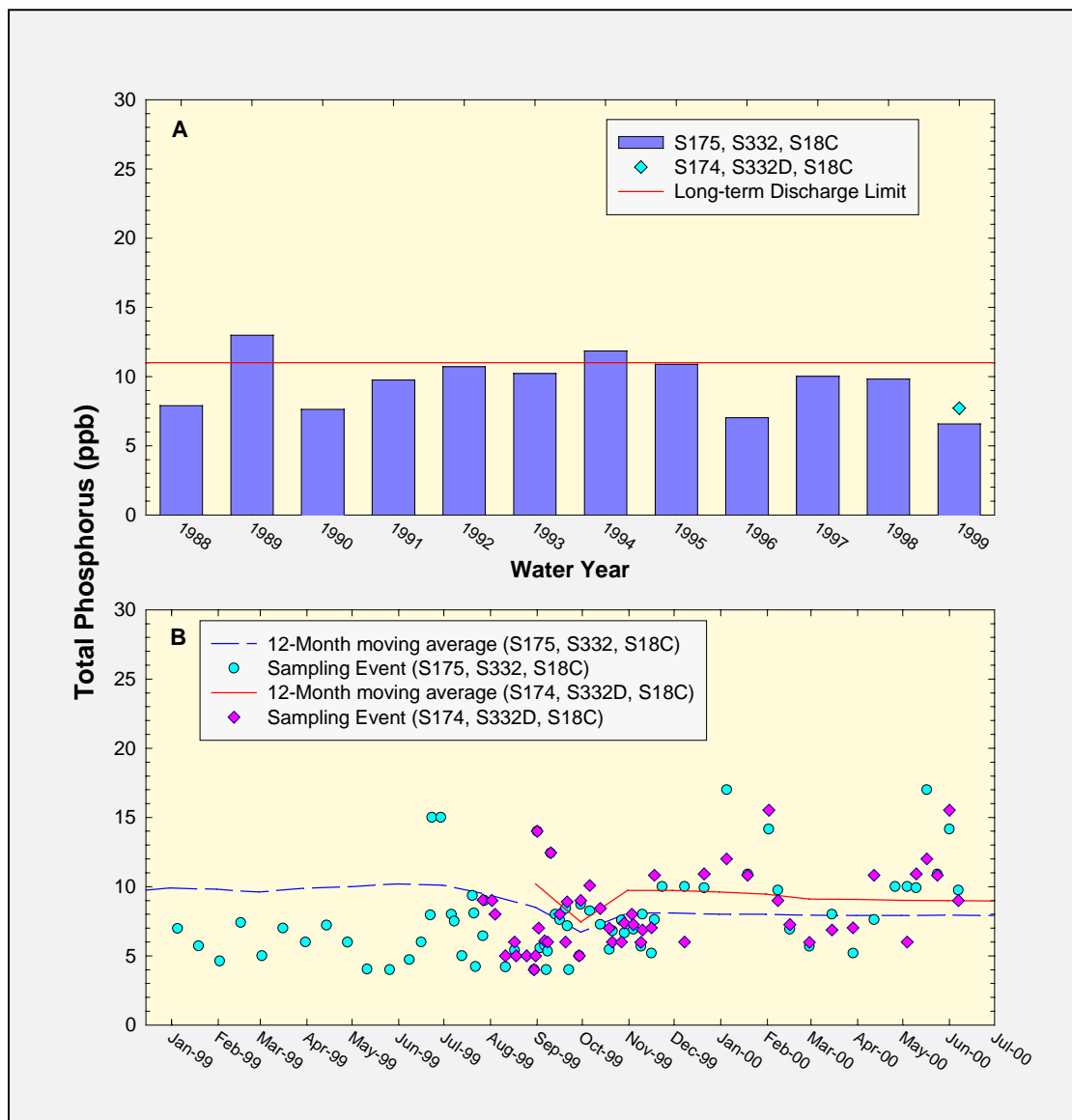
**Table 6. Taylor Slough and Coastal Basins Total Phosphorus Compliance Tracking.**

12-Month Period Ending On	Total Period Flow (ac-ft x 10 <sup>3</sup> )		Flow Weighted Mean Total Phosphorus (ppb)		Long Term Limit (ppb)	Percent of Samples Greater Than 10 ppb			
						Observed (%)		Allowed (%)	
	New	Old	New	Old		New	Old	New	Old
9/30/98	81.29	294.0	11.7	10.5	11.0	33.3	32.1	53.1	53.1
10/31/98	88.04	320.8	11.5	10.0	11.0	33.3	32.1	53.1	53.1
11/30/98	96.19	354.0	11.2	9.6	11.0	33.3	32.1	53.1	53.1
12/31/98	88.36	318.7	11.6	9.9	11.0	34.6	32.1	53.1	53.1
1/31/99	97.67	329.8	11.4	9.8	11.0	30.8	28.6	53.1	53.1
2/28/99	90.69	306.5	12.0	9.6	11.0	26.9	25.0	53.1	53.1
3/31/99	82.60	272.1	12.4	9.9	11.0	23.1	21.4	53.1	53.1
4/30/99	74.57	251.6	12.9	10.0	11.0	25.9	25.0	53.1	53.1
5/31/99	63.40	232.1	13.8	10.2	11.0	32.0	28.6	53.1	53.1
6/30/99	70.04	259.5	13.6	10.1	11.0	32.0	28.6	53.1	53.1
7/31/99	75.96	275.6	12.1	9.4	11.0	25.9	25.0	53.1	53.1
8/31/99	78.96	287.7	10.2	8.5	11.0	15.6	16.7	53.1	53.1
9/30/99	94.00	279.9	7.5	6.7	11.0	11.8	12.1	53.1	53.1
10/31/99	101.7	338.8	9.7	8.1	11.0	17.1	17.1	53.1	53.1
11/30/99	111.7	365.2	9.7	8.1	11.0	15.4	15.4	53.1	53.1
12/31/99	127.2	413.6	9.6	8.0	11.0	15.0	15.4	53.1	53.1
1/31/00	144.3	450.0	9.5	8.0	11.0	15.0	15.4	53.1	53.1
2/29/00	160.0	479.2	9.1	7.9	11.0	14.3	15.0	53.1	53.1
3/31/00	164.5	485.4	9.1	7.9	11.0	14.6	15.4	53.1	53.1
4/30/00	164.8	492.7	9.0	7.9	11.0	15.0	12.8	53.1	53.1
5/31/00	170.2	493.4	9.0	8.0	11.0	16.3	14.6	53.1	53.1
6/30/00	161.7	467.3	9.0	7.9	11.0	21.4	17.1	53.1	53.1

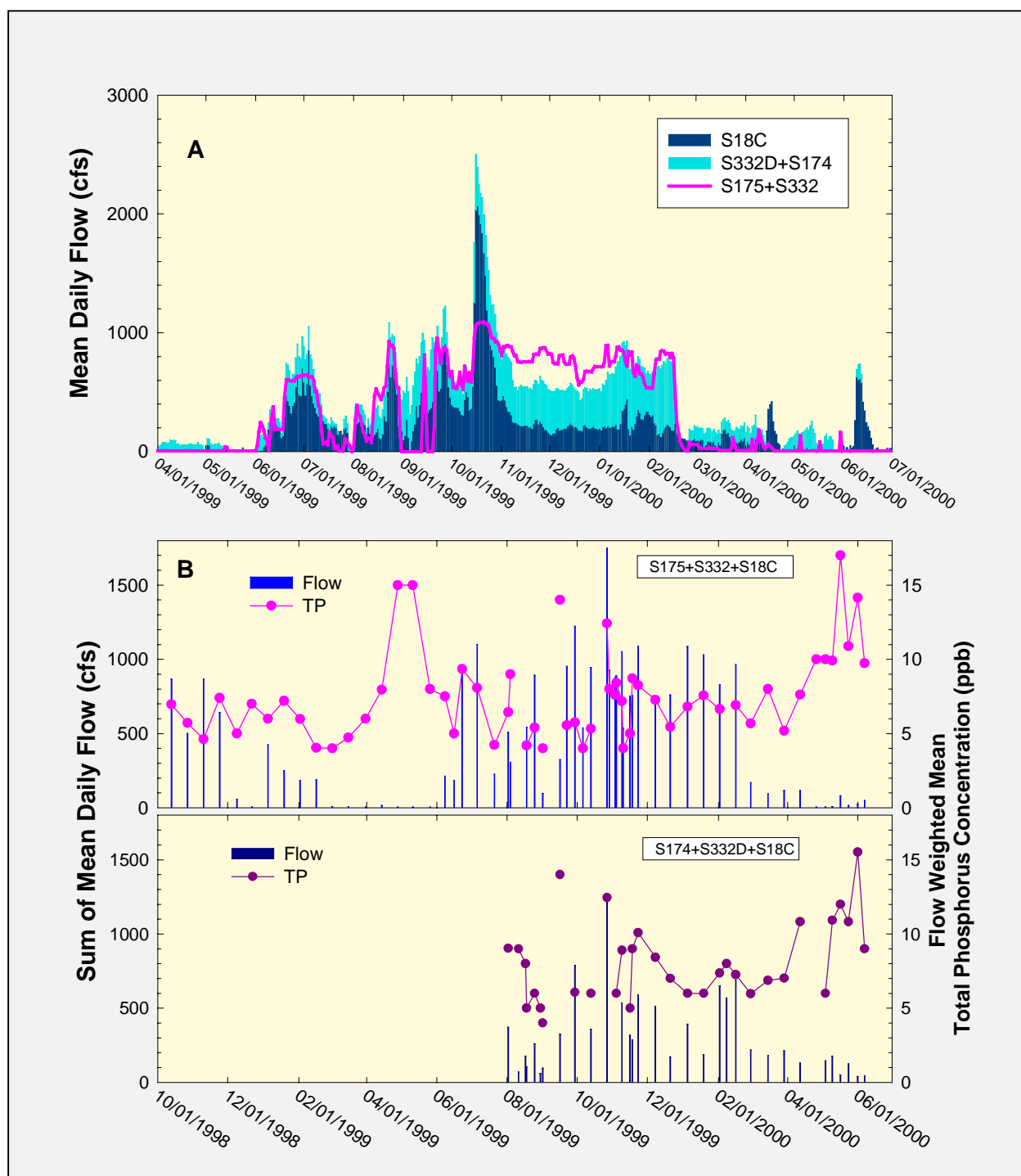
must not exceed a fixed value of 53.1 percent. The percentage of flow-weighted mean total phosphorus concentrations greater than 10 ppb for the new combination of structures was 15.0, 16.3 and 21.4 percents for the periods ending April, May and June, respectively. For the old combination of structures, the percentages were 12.8, 14.6 and 17.1 for April, May and June, respectively (**Table 6**).

A comparison of flows between the old and new combinations of structures is presented in **Figure 25**. The flow through S18C, along with the combined flows through S332 plus S175 and S332D plus S174, is presented in **Figure 25a**. The water discharged from the downstream structures, S175 and S332, is supplied through the upstream structures, S174 and S332D. However, the total flows at the downstream structures are very often greater than those at the upstream structures. As mentioned previously, this additional water is probably the result of seepage into the canal because there are no additional inflow structures in the L31W canal. **Figure 25b** shows the relationship between the sum of the daily mean flows at Taylor Slough and Coastal Basins structures and the corresponding flow-weighted mean total phosphorus concentrations for each sampling event at both the old and new combinations of structures. Total phosphorus concentrations tended to increase up to seven ppb above the

normal concentration range during extremely low flow periods at both combinations of structures. The lowering of Lake Okeechobee does not appear to have had any detectable influence at the Taylor Slough or S18C structures.



**Figure 24.** a. Flow-weighted mean total phosphorus concentration at the inflows to Everglades National Park through Taylor Slough and the Coastal Basins compared to the 11 ppb long-term total phosphorus limit for each water year. b. The 12-month moving average and individual sampling event flow-weighted mean total phosphorus concentrations at both the old and new combinations of compliance monitoring sites.



**Figure 25.** a. Daily mean flows into Everglades National Park through Taylor Slough and S18C, the Coastal Basins control structure. b. Mean daily flows and corresponding flow-weighted mean total phosphorus concentrations at old and new combinations of Taylor Slough and Coastal Basin structures.

# FLORIDA BAY

## SUMMARY

## MAP

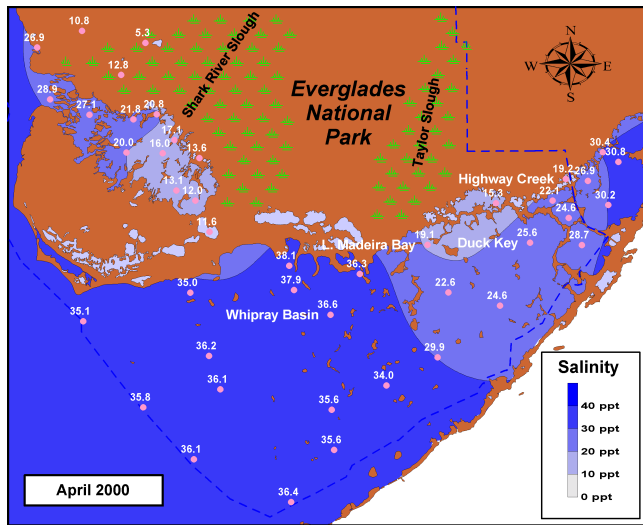
The South Florida Water Management District, in collaboration with the Everglades National Park and Florida International University, monitors water quality in Florida Bay to track the influences of fresh water inflows to the bay. Salinity and chlorophyll *a* are used as indicators of water quality within Florida Bay.

## Salinity

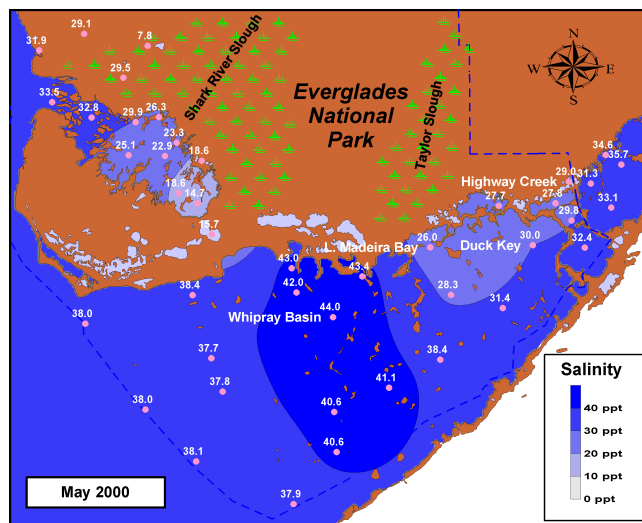
As an estuary, Florida Bay requires a properly maintained salinity regime for the overall ecological health of the bay. Salinity can be defined as the grams of salt dissolved in a kilogram of water and is expressed in units of parts per thousand (ppt). Within the bay, salinity is affected by freshwater input, in the form of rainfall and surface water runoff from the Everglades, and transport of seawater into the bay predominantly from the Gulf of Mexico. Because the bay is a shallow and wide lagoon, evaporation also affects salinity levels. When evaporation exceeds freshwater input, portions of the bay can become hypersaline. Water conditions in the bay are considered hypersaline when salinity exceeds 35 ppt, which is the approximate mean salinity of ocean water. The central portion of the bay contains small basins surrounded by shallow seagrass banks that extend toward the western edge of Florida Bay. Because of the bathymetry of this region, it is especially susceptible to hypersaline conditions.

Maps showing salinity contours within Florida Bay from April through June 2000 are depicted in **Figures 26a** through **26c**. Overall, salinity in Florida Bay during the second quarter of 2000 ranged from 7.2 to 44.1 ppt.

Salinities greater than 35 ppt were observed during all three months of monitoring in Florida Bay (**Figures 26a** through **26c**). Bay-wide salinities measured for the second quarter of 2000 averaged 30.5, 35.6 and 32.6 ppt in April, May and June, respectively. The most occurrences of salinities greater than 35 ppt were measured during the May event. The highest salinities for the second quarter were also measured during this month (**Figure 26b**). These hypersaline conditions were predominant in the central portion of Florida Bay. The lowest salinities during these three months were measured in April (**Figure 26a**). Evaporation and low freshwater input (*i.e.*, runoff and rainfall), as well as water from the Gulf of Mexico, contributed to the higher salinities observed in the bay throughout the second quarter.

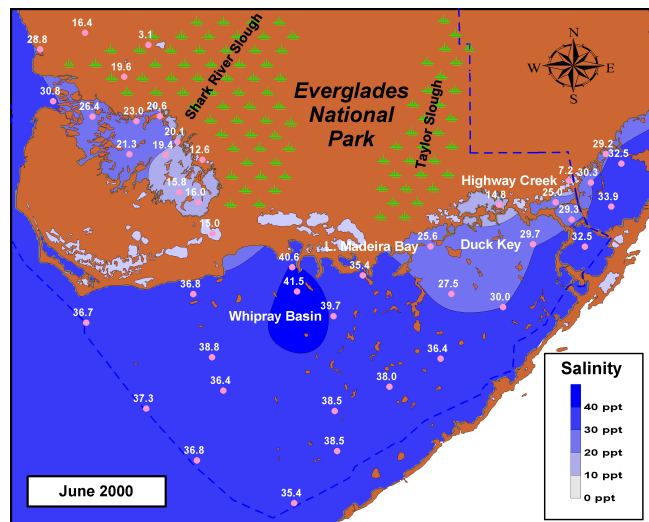


**Figure 26a.**  
Salinity in  
Florida Bay and  
the western  
coast of the  
Everglades  
National Park for  
April 2000  
(Data collected  
by Florida  
International  
University.)



**Figure 26b.**  
Salinity in  
Florida Bay and  
the western  
coast of the  
Everglades  
National Park  
for May 2000  
(Data collected  
by Florida  
International  
University.)

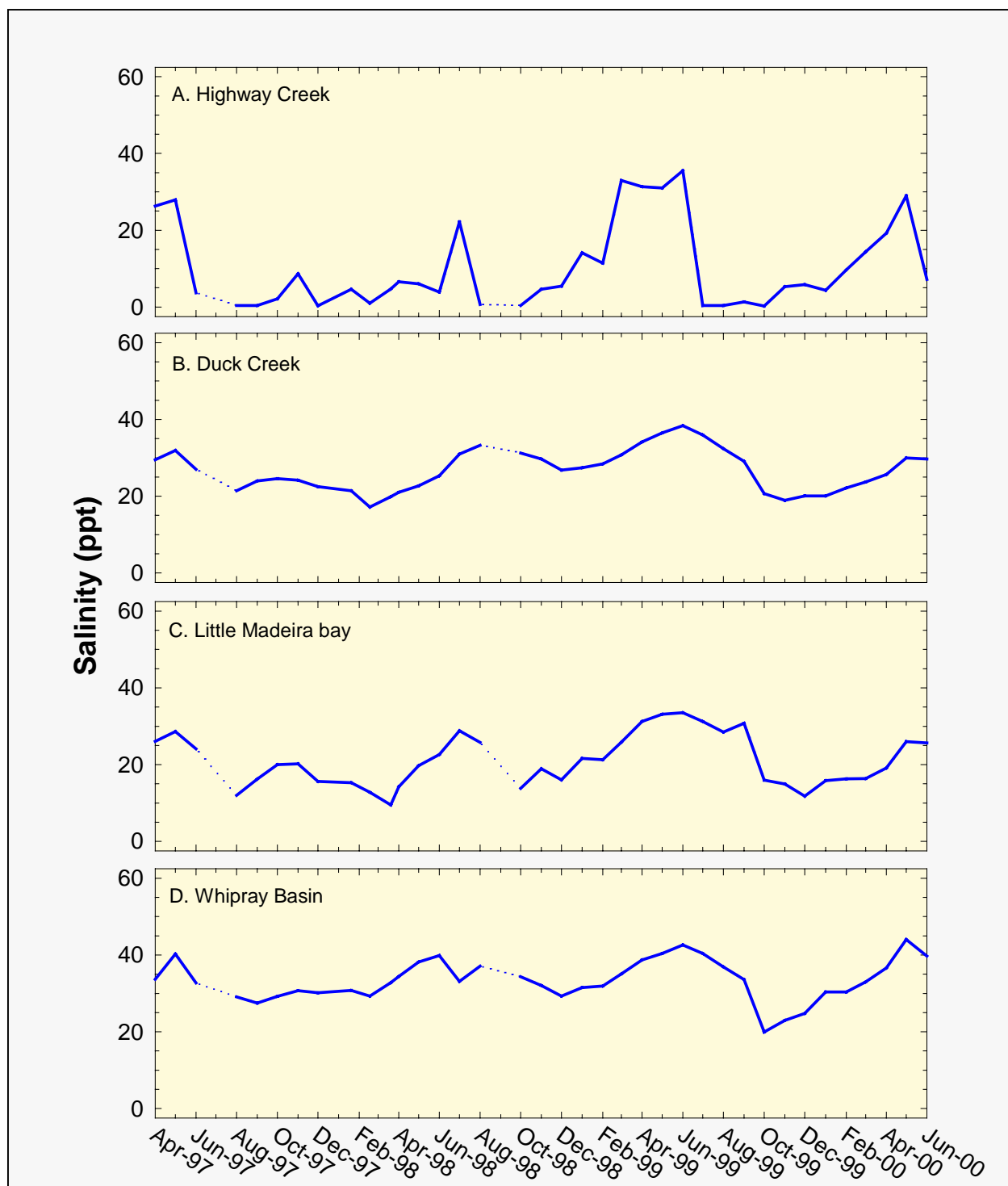
**Figure 26c.**  
Salinity in  
Florida Bay and  
the western  
coast of the  
Everglades  
National Park  
for June 2000  
(Data collected  
by Florida  
International  
University.)



Salinity levels measured over the last three years at monitoring sites in Highway Creek, Duck Key, Little Madeira Bay and Whipray Basin are presented as **Figure 27**. A summary of salinities recorded at these monitoring sites for the second quarter of 2000 is also presented in **Table 7**. An increase in salinities occurred at the four monitoring sites from April to May (**Figure 27**). By June, salinities decreased at all four monitoring sites. During the second quarter of 2000, salinity at Highway Creek varied by more than 22 ppt (**Table 7**). Due to its proximity to a freshwater source, wide salinity swings are common for this site. The other three monitoring sites exhibited smaller variations in salinity during this reporting period (**Table 7**).

**Table 7. Salinity (ppt) in Florida Bay**

	Apr-00	May-00	Jun-00
Highway Creek	19.2	29.0	7.2
Duck Key	25.7	30.0	29.7
L. Madeira Bay	19.1	26.0	25.7
Whipray Basin	36.7	44.1	39.7



**Figure 27.** Salinity at four sites in Florida Bay from January 1, 1997, through June 30, 2000 (dashed lines indicate missing data).

## Chlorophyll *a* Concentrations

Large areas of dense algal communities can affect the overall health of the Florida Bay ecosystem. Chlorophyll *a* concentrations measured in the bay are an indicator of algae (phytoplankton) biomass. Regional chlorophyll *a* concentrations in Florida Bay and the west coast of the Everglades National Park are collected monthly. The distributions of chlorophyll *a* levels measured in the bay during the first three months of 2000 are shown in **Figures 28a** through **28c**.

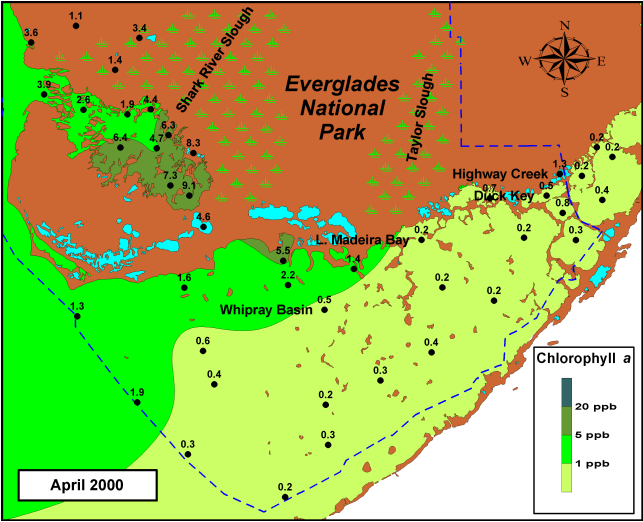
During the second quarter of 2000, chlorophyll *a* concentrations in Florida Bay averaged 0.7 parts per billion (ppb) and ranged from 0.2 to 5.5 ppb. Mean chlorophyll *a* concentrations in the bay decreased from April through June 2000. The eastern and southern portions of Florida Bay exhibited lower chlorophyll *a* levels. This trend has been reported in previous issues of this report. The highest chlorophyll *a* levels in Florida Bay were consistently observed at Garfield Bight and Rankin Basin (both areas are located directly northwest of Whipray Basin) (**Figures 28a** and **28c**). These higher chlorophyll *a* levels may be attributed to nutrient inputs to the bay from runoff as well as wind-induced, turbulent mixing resulting in the resuspension of sediments.

Chlorophyll *a* concentrations measured at four sampling stations in Florida Bay over the past three years of monitoring are shown in **Figure 29**. In addition, chlorophyll *a* concentrations measured during the second quarter of 2000 are summarized in **Table 8**. In general, chlorophyll *a* levels measured at these sites during the second quarter of 2000 were similar to those measured for the same period in the previous year.

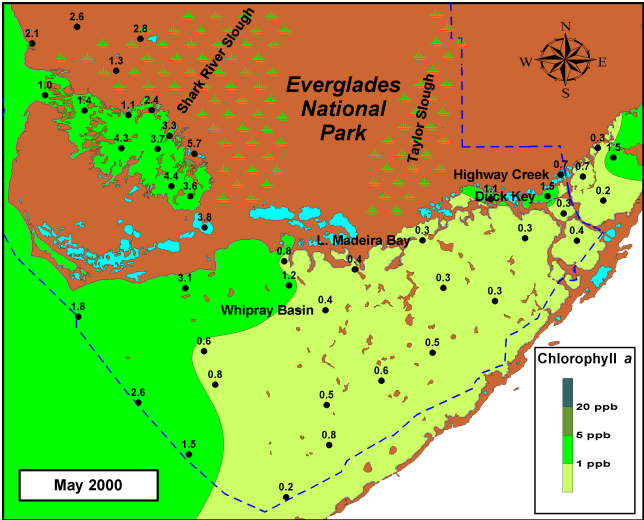
During second quarter of 2000, Highway Creek exhibited a decrease in chlorophyll *a* levels (**Table 8**). Meanwhile, chlorophyll *a* levels were relatively unchanged at the other three monitoring stations.

**Table 8. Chlorophyll *a* (ppb) in Florida Bay**

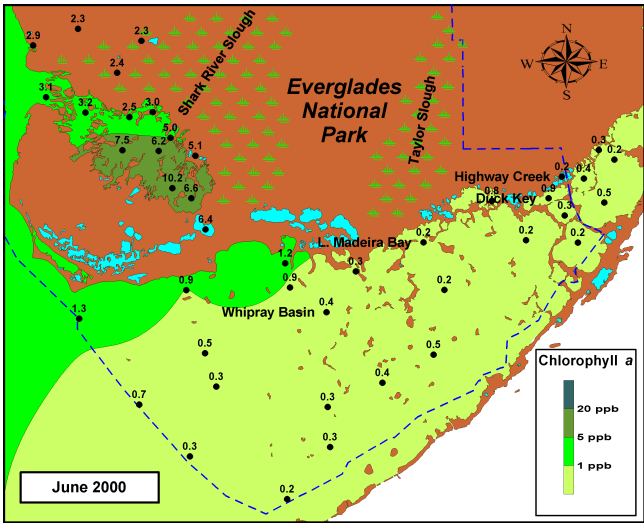
	Apr-00	May-00	Jun-00
Highway Creek	1.3	0.7	0.2
Duck Key	0.2	0.3	0.2
L. Madeira Bay	0.2	0.3	0.2
Whipray Basin	0.5	0.4	0.4



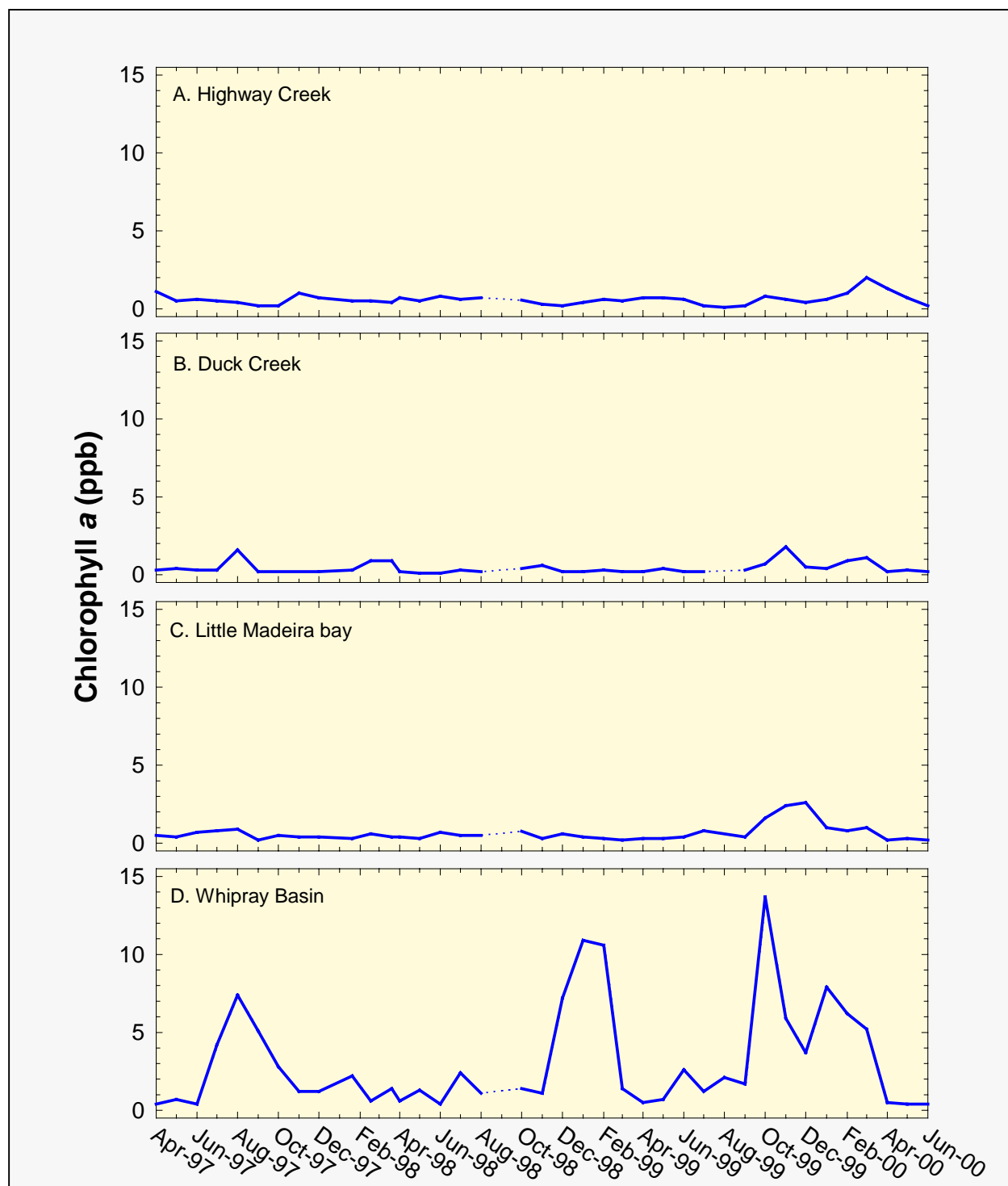
**Figure 28a.**  
Concentrations of chlorophyll *a* in Florida Bay and the western coast of Everglades National Park for April 2000. (Data collected by Florida International University.)



**Figure 28b.**  
Concentrations of chlorophyll *a* in Florida Bay and the western coast of Everglades National Park for May 2000. (Data collected by Florida International University.)



**Figure 28c.**  
Concentrations of chlorophyll *a* in Florida Bay and the western coast of Everglades National Park for June 2000. (Data collected by Florida International University.)



**Figure 29.** Chlorophyll *a* concentrations at four sites in Florida Bay from April 1, 1997, through June 30, 2000 (dashed lines indicate missing data).

# PESTICIDE MONITORING PROGRAM

## SUMMARY

## MAP

As part of the District's quarterly ambient monitoring program, unfiltered water and sediment samples from 36 sites were collected from May 1 to May 4, 2000, and analyzed for over 60 pesticides and/or products of their degradation. The herbicides ametryn, atrazine, bromacil, diuron, hexazinone, metolachlor, norflurazon, and simazine, along with the insecticides/degradates atrazine desethyl, atrazine desisopropyl, and endosulfan sulfate, were detected in one or more of these surface water samples. None of the detected compounds have a numerical criterion as adopted under the Florida Class III Water Quality Standards for surface water (Chapter 62-302), nor do they exceed the acute or chronic calculated toxicity standards (FAC 62-302.200). However, the highest surface water concentrations of atrazine found in this sampling event (4.4 µg/L at S38B and 5.7 µg/L at S8) could inhibit algal cell multiplication. This level also exceeded the Florida Ground Water Guidance Concentrations of 3 µg/L. Impacts to human health could result if this water were used as a source of drinking water. Possible impacts could occur to the base of the food chain.

The herbicide ametryn, together with the insecticides/degradates DDD, DDE, DDT, chlordane, alpha endosulfan, beta endosulfan, endosulfan sulfate, and ethion, were found in the sediment at several locations, along with one PCB compound. Some of the detected sediment concentrations of DDD, DDE, and DDT are usually associated with the potential for impacting wildlife when compared to coastal sediment quality assessment guidelines. The chlordane, one of the DDT and three of the DDD detections were of a magnitude considered to represent significant and immediate hazard to aquatic organisms. However, there are no corresponding freshwater sediment quality assessment guidelines.

Data for 23 of the 36 sites are reported for information purposes only (**Table 9**) as, during this particular sampling event, appropriate quantities and frequencies of the field quality control checks were not performed for these samples. Data are flagged as an estimated value and may not be accurate.

The District's pesticide monitoring network includes stations designated in the Everglades National Park Memorandum of Agreement, the Miccosukee Tribe Memorandum of Agreement, the Lake Okeechobee Operating Permit, and the Non-Everglades Construction Project (Non-ECP) permit. Surface waters are sampled quarterly and sediments semiannually.

### Surface Water and Sediment Findings

At least one pesticide was detected in surface water at 35 of the 36 sites, and in sediment at 15 of the 34 sites. Sediment samples are not collected at GORDYRD and CR33.5T. The concentrations of the pesticides detected at each of the sites are summarized for the surface water and sediment in **Tables 9 and 10**, respectively. Each of these compounds has previously been detected in this monitoring program.

No ethion was detected in the surface water at any of the sampling sites. Since April 1996, seven out of 17 sampling events at S99 had a detectable level of ethion in the surface water. With the method detection limit around 0.02 µg/L, any detection will automatically exceed the calculated chronic toxicity (0.003 µg/L) for *Daphnia magna*.

No endosulfan ( $\alpha$  plus  $\beta$ ) was detected in the surface water during this sampling event. The January 1996 and February 2000 sampling events at S178 were the last times the surface water concentrations exceeded the Florida Class III surface water quality standard (Chapter 62-302). Endosulfan was quantified in the sediment at S178 and S177.

The above findings must be considered with the caveat that pesticide concentrations in surface water may vary significantly with relation to the timing and magnitude of pesticide application, rainfall events, pumping and other factors, and that this was only one sampling event. The possible long-term or chronic toxicity impacts are also reported based on the single sampling event and do not take into account previous monitoring data.

**Table 9.** Summary of pesticide residues above the method detection limit found in surface water samples collected by SFWMD in May 2000.

DATE	SITE	FLOW	COMPOUNDS (µg/L)											Number of compounds detected at site
			ametryn	atrazine	atrazine desethyl	atrazine desisopropyl	bromacil	diuron	endosulfan sulfate	hexazinone	metolachlor	norflurazon	simazine	
5/1/00	S18C (1)	N	-	0.066	-	-	-	-	-	-	-	-	-	1
	S178 (1)	N	-	-	-	-	-	-	0.19	-	-	-	-	1
	S177 (1)	Y	-	0.062	-	-	-	-	-	-	-	-	-	1
	S332 (1)	Y	-	0.11 *	0.012 I*	-	-	-	-	-	-	-	0.012 I*	3
	S176 (1)	Y	-	0.018 I	-	-	-	-	-	-	-	-	-	1
	S331 (1)	Y	-	0.012 I	-	-	-	-	-	-	-	-	-	1
	G211 (1)	Y	-	0.0099 I	-	-	-	-	-	-	-	-	-	1
5/2/00	US41-25 (1)	N	-	0.018 I	-	-	-	-	-	-	-	-	-	1
	S12C (1)	N	-	0.017 I	-	-	-	-	-	-	-	-	-	1
	S31 (1)	Y	0.017 I*	0.38 *	0.033 I*	-	-	-	-	-	-	-	-	3
	S9 (1)	N	-	-	-	-	-	-	-	-	-	-	-	0
	G123 (1)	N	0.042 I	1.9	-	0.022 I	-	-	-	-	0.063 I	-	0.037 I	5
	S142 (1)	N	0.051	0.56	-	-	-	-	-	-	0.061 I	-	0.013 I	4
	S38B (1)	N	0.010 I	4.4	-	0.028 I	-	-	-	-	-	-	0.013 I	4
5/3/00	S140 (1)	N	-	0.040 I	0.013 I	-	-	-	-	-	-	-	-	2
	S190 (1)	N	-	0.13	-	-	-	-	-	-	0.092 I	0.077 I	-	3
	L3BRS (1)	N	-	0.33	0.042 I	-	2.7	0.56	-	-	0.22 I	-	-	5
	S8 (1)	N	0.099	5.7	0.27	0.036 I	-	-	-	0.11	-	-	0.021 I	6
	S7 (1)	N	0.013 I	0.44	0.044 I	-	-	-	-	-	-	-	0.018 I	4
	S6 (1)	N	0.055	0.45	0.027 I	-	-	-	-	-	-	-	0.011 I	4
	S5A (1)	Y	0.013 I	0.72	0.046 I	-	-	-	-	-	-	-	0.014 I	4
	ACME1DS (1)	N	0.096	0.41	0.022 I	-	-	-	-	-	-	-	-	3
	G94D (1)	N	0.1	0.35	0.019 I	-	-	-	-	-	0.019 I	-	-	3
	S2	N	0.013 I	0.46	0.043 I	-	-	-	-	-	-	-	0.038 I	4
	S3	N	0.014 I	0.5	0.036 I	0.014 I	-	-	-	-	-	-	0.044 I	5
	S4	N	0.011 I*	0.37 *	0.046 I*	-	-	-	-	-	-	-	0.027 I*	4
	S235	R	0.056	0.93	0.06	-	-	-	-	-	-	-	0.022 I	5
	S78	Y	-	0.27	0.039 I	-	-	-	-	-	-	-	0.012 I	3
	CR33.5T	Y	-	0.34	0.047 I	-	-	-	-	-	-	-	0.030 I	3
	S79	Y	-	0.33	0.031 I	-	-	-	-	-	-	-	0.023 I	3
5/4/00	FECSR78	N	-	0.044 I	-	-	-	-	-	-	-	-	-	1
	S65E	N	-	0.094	0.013 I	-	-	-	-	-	-	-	-	2
	S191	N	-	0.025 I	-	-	-	-	-	-	-	-	-	1
	GORDYRD	N	-	-	-	0.022 I*	0.76 *	0.29 I*	-	-	-	0.61 *	0.33 *	5
	C25S99	N	-	-	-	-	0.19 I	0.29 I	-	-	-	0.59	0.13	4
	S80	Y	-	0.16	0.028 I	-	-	-	-	-	-	0.040 I	-	3
Total number of compound detections			14	32	19	5	3	3	1	1	4	4	17	

Data reported for information purposes only. Appropriate quantities and frequencies of the field quality control checks were not performed for these samples. Data is flagged as an estimated value; value not accurate. N – no Y – yes  
R – reverse ; - denotes that the result is below the MDL; \* - results are the average of duplicate samples;  
I - value reported is less than the minimum quantitation limit, and greater than or equal to the minimum detection limit

**Table 10.** Summary of pesticide residues above the method detection limit found in sediment samples collected by SFWMD in May 2000

DATE	SITE	COMPOUNDS (µg/Kg)										Number of compounds detected at site
		ametryn	DDD	DDE	DDT	chlordane	alpha endosulfan	beta endosulfan	endosulfan sulfate	ethion	PCB1260	
5/1/00	S178	-	-	74	-	-	-	8.5	26	-	-	3
	S177	-	-	7.8	-	-	2.5 I	5.1	-	-	-	3
	S176	-	-	-	-	-	-	-	-	17 I	-	1
5/2/00	S31	-	-	13 I*	-	-	-	-	-	-	-	1
	S142	7.6 I	-	5.0 I	-	-	-	-	-	-	-	2
5/3/00	S7	5.7 I	1.7 I	10	-	-	-	-	-	-	30 I	4
	S6	8.5 I	14	54	8.7 I	43 I	-	-	-	-	-	5
	S5A	-	9.5	23	-	-	-	-	-	-	190	3
	ACMEIDS	-	-	4.9 I	-	-	-	-	-	-	-	1
	G94D	-	2.0 I	8.8	-	-	-	-	-	-	-	2
	S2	-	3.3 I	11	3.9 I	-	-	-	-	-	-	3
	S3	-	24	22	-	-	-	-	-	-	-	2
	S4	29 I*	5.0 I*	47 *	-	-	-	-	-	-	-	3
	S235	-	-	18 I	-	-	-	-	-	-	-	1
	S79	-	-	11 I	-	-	-	-	-	-	-	1
Total number of compound detections		4	7	14	2	1	1	2	1	1	2	

- denotes that the result is below the MDL; \* - results are the average of duplicate samples; I - value reported is less than the minimum quantitation limit, and greater than or equal to the minimum detection limit

## REFERENCES

- F.A.C. Chapter 94-115. Everglades Forever Act. Senate Bill #1250. Section (4), subsection (d).
- FDEP. 1994. Permit Number 502232569 issued February 18, 1994.
- FDEP. 1997. Permit Number 262918309 issued July 7, 1997.
- Germain, G. 1998. Surface water quality monitoring network South Florida Water Management District. Technical Memorandum DRE 356. Resource Assessment Division, Water Resources Evaluation Department, South Florida Water Management District, West Palm Beach, FL.
- SFWMD. 1997. Surface Water Improvement and Management (SWIM) Plan - Update for Lake Okeechobee. Vol. 1. South Florida Water Management District, West Palm Beach, FL.
- SFWMD. 1995. South Florida Ecosystem Restoration Plan. Everglades Restoration Department. South Florida Water Management District, West Palm Beach, FL.
- SFWMD. 1997-1998. The Everglades Nutrient Removal Project Discharge Monitoring Report. Water Resources Evaluation Department, South Florida Water Management District, West Palm Beach, FL. December 1997 through December 1998 issues.
- SFWMD. 1997-1999. Water Quality Conditions Quarterly Report. Water Resources Evaluation Department, South Florida Water Management District, West Palm Beach, FL. January 1997 through October 1999 issues.
- SFWMD. 2000a. Surface Water Conditions Report. Operations Management Department, South Florida Water Management District, West Palm Beach, FL. January 1998 through December 1999 issues.
- SFWMD. 2000b. Water Quality Conditions Quarterly Report. Environmental Monitoring and Assessment Division, South Florida Water Management District, West Palm Beach, FL. July 2000 issue.
- SFWMD. 2000c. Pesticide Surface Water Quality Report. Water Resources Evaluation Department, South Florida Water Management District, West Palm Beach, FL. December 1999 sampling event.
- SFWMD, 2001. 2001 Everglades Consolidated Report. Garth Redfield (Ed.), Environmental Monitoring and Assessment Division, South Florida Water Management District, West Palm Beach, FL. (Work in progress)
- US District Court. 1995. Modifications to the Settlement Agreement (1991). Case No. 88-1886-CIV-HOEVELER. June 20, 1995. Appendices A and B.

# GLOSSARY

**12-month moving average**

The mean (arithmetic average) of data from 12 consecutive months. As the latest month is added to the data set, the earliest month is dropped from the data set

**5-year moving average**

The mean (arithmetic average) of data from 5 consecutive annual averages of sums. When the latest year is added to the data set the earliest year is dropped from the data set.

**flow-weighted mean**

The arithmetic average adjusted for flow:

$$\bar{x} = \frac{\sum_{i=1}^{i=n} q_i c_i}{\sum_{i=1}^{i=n} q_i}$$

q = flow  
c = concentration

**geometric mean**

The nth root of individual data values that have been multiplied:

$$G = \sqrt[n]{x_1 x_2 \dots x_n}$$

**EC<sub>50</sub>**

A concentration necessary for 50 percent of the aquatic species tested to exhibit a toxic effect short of mortality within a short exposure period, usually 24 to 96 hours.

**units of concentration measurement**

(assuming density of water = 1.0)

grams/kilograms	(g/kg) =	1 part /thousand (ppt)
milligram/Liter	(mg/L) =	1 part/million (ppm)
microgram/Liter	(µg/L) =	1 part/billion (ppb)
nanogram/Liter	(ng/L)	



FOR MORE INFORMATION  
C O N T A C T

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